United States Department of Agriculture

Investigations

In

GRAND PRAIRIE RICE REGION, ARKANSAS

For

FARM CREDIT ADMINISTRATION

By

Bureau of Agricultural Engineering
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INTRODUCTION

This is a report by the Bureau of Agricultural Engineering, United States Department of Agriculture, describing the results of a survey made in the Grand Prairie rice-growing region of Arkansas during the Summer of 1934 for the Farm Credit Administration, and setting forth the conclusions of the party which made it. The investigation had to do, in general, with the circumstances then existing in the Grand Prairie as they appeared to affect the security represented by the rice farms for Federal Farm Loans. In particular, it dealt with the status of the water supply, upon which the profitable growing of rice is dependent to a degree much greater than that represented by any other physical influence.

The survey was initiated by the following request by Governor W. I. Myers, of the Farm Credit Administration, addressed to the Secretary of Agriculture:

"FARM CREDIT ADMINISTRATION
"Washington, D.C.

"June 21, 1934.

"The Honorable,
"The Secretary of Agriculture.

"Dear Mr. Secretary:

"The Federal Land Bank of St. Louis has not been making loans in about three-fourths of the area of the Grand Prairie Rice Region of Arkansas for some time because the bank has felt that such loans would be hazardous on account of a diminishing water supply for irrigation, which supply is obtained by pumping from wells. On the other hand, the land owners in the restricted area claim that their water supply is dependable and adequate and that their lands are capable of producing profitably even if the irrigation supply fails. They claim further that supplemental water can be obtained economically by storage of surface run-off during the winter time.

"The demand for farm loans in this area necessitates some independent and unprejudiced investigations by competent engineers of the adequacy, permanence and economy of the present ground water supply; of the best plan for procuring supplemental water, and of the suitability and value of the lands for producing profitable crops without irrigation. Other phases of the investigation would include the questions of water right legislation, quality of the water supply and the total irrigable area of the rice region.

I will appreciate it if your Department will undertake through the appropriate bureaus the investigations suggested in this letter, the expense to be borne by the land bank system. It is my understanding that the Bureau of Agricultural Engineering is the best equipped organization for undertaking the engineering features of this investigation but I am not sure which bureau should undertake that part of the investigation pertaining to the suitability of soils for dry farming and quality of water supplied.

"Because the demand for loans in this section is quite urgent, I will appreciate it if you can make arrangements to carry out this investigation at an early date. I will be glad to have a statement from you regarding the cost of the undertaking. The Land Bank Division will cooperate in any way possible by furnishing such material as may be available, either here or in the St. Louis Federal Land Bank that might be helpful to the investigators.

"Sincerely yours,

"(SGD) W. I. Myers
"Governor"

Governor Myers' request was acceded to by Secretary Wallace in the letter quoted below:

Dear Governor Myers:

"I have your letter of June 21, in regard to your desire for a study of the Grand Prairie Rice Region of Arkansas.

"The Department will be glad to undertake the study that you request with the understanding that the expenses will be borne by the Farm Credit Administration. I am asking Mr. S. H. McCrory, Chief of the Bureau of Agricultural Engineering, to take the responsibility of correlating the activities of the different bureaus which may be concerned in this undertaking.

"Sincerely,

(SGD) "H. A. Wallace
"Secretary"

The party organized by Mr. McCrory in accordance with the instructions of Secretary Wallace consisted of the following members of the staff of the Bureau of Agricultural Engineering: B.S. Clayton, Associate Drainage Engineer, of the Division of Drainage, and Paul A. Ewing, Associate Irrigation Economist, of the Division of Irrigation. Mr. Clayton and Mr. Ewing met on July 2 at the offices of the Federal Land Bank of St. Louis, where they obtained from officials of the Bank much detailed information regarding the experience of the Bank with the loans

it had made in Grand Prairie and its negotiations with the farmers since discontinuing its early policy of making loans on rice farms. They then proceeded to Little Rock, where similar conversations were held with various interested officials of the State of Arkansas. From Little Rock they went to Stuttgart, where because it is centrally located in the Grand Prairie area and is the seat of the Rice Branch Experiment Station of the University of Arkansas, they made their field headquarters. There they were joined late in July by T. F. Akers, Assistant Agronomist, of the division of Forage Crops, Bureau of Plant Industry, to whom had been delegated the task of studying the present and possible position of other crops than rice in the agriculture of the Grand Prairie. While at the outset Mr. Akers had expected to contribute a chapter to the report of the entire survey, later necessities resulted in his report being submitted separately; the present report, threfore, gives merely incidental attention to the subject discussed by him in full elsewhere.

This report was written immediately upon the conclusion of the field survey, in August, 1934. In its preparation the authors were greatly assisted by the liberal cooperation of Dr. C. O. Brannen, Acting Dean of the College of Agriculture, University of Arkansas, and G. H. Banks, Assistant Director in charge of the University's Rice Branch Experiment Station at Stuttgart; Dr. George H. Branner, State Geologist; various citizens of the Grand Prairie area; and members of the engineering staff of the Federal Land Bank of St. Louis, who furnished promptly upon request copies of many records bearing upon conditions in the area, which the Bank had previously assembled.

SUMMARY

The Grand Prairie is an area of about 600,000 acres in Southeastern Arkansas. It comprises the greater part of Arkansas County, the east-central part of Lonoke County, the southern half of Prairie County, and the small portion of Monroe County which is west of White River. Stuttgart is its largest city and chief marketing and distributing center.

The average elevation is about 200 feet above sea level, the range being from about 230 feet in the northern portions to about 180 feet at the southern end. The topography is extraordinarily uniform, ranging from nearly level to undulating and gently rolling. On account of the even slope the drainage of much of the area is slow, necessitating the assistance of various artificial courses, especially in rice-growing sections.

The climate of Grand Prairie is humid, with long hot summers and short winters. The mean annual temperature at Stuttgart is 62.6 F. The mean annual precipitation is 51.01 inches with a minimum of 40.22 inches in 1929 and a maximum of 69.13 inches in 1906. In the average year the fall months are the driest and the spring season is the wettest. The average date of the last killing frost in the spring is March 25 and of the first in the fall, October 30, This gives an average growing season of 219 days.

The typical soil of the Grand Prairie is the Crowley silt loam, which is friable and of excellent tilth. The lower subsoil is compact and very nearly impervious to water. The Crowley silt loam is strongly acid in its native condition, but this acidity is said to be somewhat ameliorated by the mineral content of the well water used in irrigation.

The area is well supplied with transportation. Two railroad systems cross the area, while both the White and Arkansas Rivers normally are navigable to points adjoining the Prairie. Freight trucking is on the increase and about as much rice leaves Stuttgart by truck as is shipped by rail. All of these factors combine to make the Prairie an excellent rice producing area. The necessary water is secured mainly from shallow wells which are usually owned by individual farmers.

It appears that rice growing in this area has been very profitable during "good times", but has suffered severely at times when the price of rice was below normal. A substantial reduction in the cost of raising rice has taken place since the present hard times set in.

The average irrigated farm in the area is 349 acres in extent, while the average unirrigated farm includes only 54 acres. The rice farms are exceptionally well-improved.

Present proportions of farms and areas mortgaged are high, but not so high as popularly supposed. The present average interest rate is not extreme. The onerous feature of the present mortgage situation is, therefore, not the average interest rate in itself, but the excessively large loans upon which it is assessed, and refunding of present mortgages would appear prospectively to involve a severe reduction of present amounts. If $ 20.05 per acre were to represent the basis of a refunding of all the present mortgages, their total would be reduced to approximately $ 2,850,000.

While the record of loans already made by the Federal Land Bank shows some delinquencies, it alone would not justify the exclusion of any extensive portion of the Prairie as an undesirable loan area. If future loans are made, they should be based on conservative valuations such as are represented by the Bank's loans now outstanding.

Crop loans formerly were made on the more or less universal basis of $20 per planted acre. Last year's averages for the Stuttgart Production Credit Association ranged from $ 10 to $ 15 per acre. In 1934 the average is more nearly $ 17.50 per acre, the increase being induced by the recent rise in costs. Many notes written to finance equipment purchased 12 to 15 years ago have been cleared up, but many new purchases cannot be postponed much longer, and some considerable financing will probably be necessary to permit them.

The tax assessed for general purposes against 301 farms in two Arkansas County townships in the last assessment, average 30.7 cents per acre. The assessed valuation was $11.92 per acre. The ratio of tax to assessed valuation was $ 2.57 per $100. Assessed valuation is obviously well below actual value. In addition to general and school taxes, a considerable portion of Grand Prairie is taxed by drainage and levee districts. Average burden represented by present taxation is neither relatively nor actually a heavy one, and liberal relief to tax delinquents has lately been provided by enactments of the State Legislature.

Notwithstanding this relief, the delinquencies in Grand Prairie have increased substantially during the past five years, and were not being fast reduced in the Spring of 1934, but relative to the corresponding circumstances elsewhere in the State, the delinquency situation in Grand Prairie is fairly good, although delinquencies involving recent taxes are far more numerous than those for the tax year 1928-9. This fact should cause greatest concern to those interested in the security established by the titles to property, and ought to have the earliest possible corrective attention if the credit of the land is to be re-established.

County bond assessments by Arkansas and Prairie Counties are made on account of bonds on which there is no delinquency. Road improvement district bonds need not be considered as local obligations, as their exchange for the State's refunding bonds is about to take place.

The drainage of the Grand Prairie is generally adequate for the satisfactory removal of the surface waters and to permit the successful farming of the land in the area. The financial status of none of the drainage districts is such as to constitute a reason why the lands involved should be considered poor credit risks. This is not true as regards Farelly Lake Levee District, which has been in default on its obligations for several years.

The acreage planted to rice reached 145,000 acres in 1920, and a maximum of 161,000 in 1926. The allotments assigned by the Agricultural Adjustment Administration for 1934 amounted to approximately 106,000 acres. The generally recognized necessity to rest the land between rice crops effects a

control over the acreage devoted to rice which appears to prevent a future approach to the maximum acreage reached in 1926. Rotations have now become so well established as to hold down the acreage, regardless of other influences. Only a few hundred acres of Prairie land remain unbroken.

Water for irrigation in the Grand Prairie is now obtained from four sources as follows:

(1) Directly from streams; (2) small reservoirs: (3) deep wells; (4) shallow wells. Nearly 5,000 acres are now irrigated from streams. The average lifts vary from 30 to 50 feet. One of the plants pumping from White River has irrigated as much as 4,000 acres. It is not probable thatmuch additional acreage will be irrigated by water pumped directly from streams. The present policy of the War Department is opposed to further diversions of the low water flow of White River on account of navigation requirements. It is now occasionally necessary to pump water from the Arkansas River into Bayou Meto in order to supply two of the plants pumping directly from that stream.

Small reservoirs have been built having an estimated capacity sufficient to irrigate about 4,000 acres. Plans for new reservoirs of this type, if executed, will provide water for an additional 7,000 acres. Such reservoirs provide an economical and dependable water supply. The total annual cost of water from this source will probably not exceed $5.00 per acre served unless conditions are exceptional. A reservoir holding an average depth of 5 feet of water, when irrigation begins, will have a sufficient capacity to irrigate twice its area in rice. The average summer rainfall at Stuttgart is 11.2 inches. This has varied during a 47-year period from 2.56 inches to 20.39 inches, and it is estimated that 12 inches of the annual rainfall can be pumped from a drainage area adjacent to a reservoir and stored for irrigation use.

The Greers Ferry project proposes to store 400,000 acre-feet of water in a reservoir on the Little Red River, and irrigate 125,000 on the Grand Prairie at a capital cost of $ 69.00 per acre, and a total annual cost of $4.50 per acre for irrigation. The project though physically possible is of such size that there seems little chance of its being built and its economic feasibility is questionable.

The Farmers' Water and Irrigation Company project proposes to construct a reservoir in the Bayou Meto bottoms and irrigate 15,000 acres north of Stuttgart. If this proves profitable, it is planned to build a second one. The estimated investment is $538,500 and the total operating cost exclusive of interest is estimated at approximately $3.00 per acre. The project is well planned, but success in securing the necessary 15,000 acres to irrigate will depend on the rental price asked for water.

Other large reservoirs have been proposed to irrigate portions of the Grand Prairie but there seems to be little chance for their construction.

The Grand Prairie is underlaid with two distinct water bearing beds or horizons. The shallow wells secure water from the upper or Pleistocene beds; the deep wells draw water from the lower or Tertiary beds.

There are now 9 deep wells in use. These vary in depth from 440 to 900 feet and discharge from 900 to 2000 g.p.m. A deep well with pump and motor of sufficient capacity to irrigate 160 acres will cost approximately $ 50 per acre served The total annual cost of operation, including fixed charges will be approximately $10 per acre at present power rates. The deep well sands constitute a reserve water supply and, while the safe yield of this stratum is not known, it is safe to say that a somewhat greater number of deep wells could be used without seriously depleting this source of irrigation water.

There are nearly 1,000 shallow wells in the Grand Prairie. The average depth is approximately 140 feet; the average depth of water in the spring of 1934 was about 76 feet; the average discharge per well is approximately 750 g.p.m.; and the average area served is probably 130 acres. The safe yield of the shallow well sands is estimated to be sufficient to irrigate a little less than 100,000 acres but due to the limitation of the data used the safe acreage may vary substantially from the above figure. The average drop in the static level of shallow wells for the five-year period 1929 to 1934 is estimated at a little under 4.5 feet. The drop during the last year of this period ending in the spring of 1934 was approximately 0.2 feet.

It is probable that the rate of drop in water levels abovenoted will decline during the next 10 or 15 years. The summer rainfall during the period 1929 to 1934 was sub-normal so that the irrigation requirements will probably be decreased in the future, the development of other sources of supply will decrease the demand on the shallow well sands, and the rice acreage cannot be greatly increased.

On account of the great variations in the geological conditions affecting the Pleistocene beds beneath the Grand Prairie, the water supply for each farm should be appraised separately. The depth of water in wells, drawdown, fall in static levels since 1929, and the geological situation of each farm should be considered in determining the probable life of the supply of irrigation water.

Without doubt there are certain areas of the Grand Prairie where the life of the shallow well supply is much more questionable than others. The most important considerations are the depth of water in the wells, the capacity of the sands, the drop in the past 5 years, and special geological conditions such as the effect of the ridge previously mentioned on the well levels of the area east of it. The shallow well supply west of this ridge and north of the Base Line (or southern line of T 1 N) appears to be ample for a long period. Of the remaining portion, special care should be used in estimating the life of the supply in T 1 S, R 5 W; T 2 S, R 5 W; T 3S, R 5W; T 4 S, R 5 W; E 1/2 of T 5 S, R 5 W; also in T 5 S, R 4 W; T 4 S, R 4 W; T 3 S, R 4 W; W 1/2 and SE 1/4 of T 2 S, R 4 W; and the W 1/2 of T 1 S, R 4W. Of the townships listed, probably the water supply beneath T 3 S, R 4 W and T 3 S, R 5 W is the most questionable.

It is probable that the heavy pumping of the past summer due to the deficiency and bad distribution of rainfall, will cause a further recession in well levels, notwithstanding the decrease in acreage.

The continued drop in well levels will cause some increase in the cost of pumping, but during the next 15 years this will not cause much increase in the total costs of irrigation. Power rates now average about $ 2.00 per acre less than those common a few years ago, while the price of fuel oil is about the same. The introduction of the light, high-speed type of oil engines has greatly decreased the cost of pumping by engine power, but their durability is a matter of question.

As the amount of water pumped has undoubtedly exceeded the recharge of the shallow well sands, the development of additional sources of water supply should be encouraged. More complete data should be secured on shallow wells, and in particular a large number of them should be measured in the spring of 1935. The necessity for conserving the shallow well supply extends beyond any loan period and a method of financing a systematic study of the factor affecting this supply should be found.

CONCLUSION AND RECOMMENDATIONS

It appears that the circumstances which led the Federal Land Bank of St. Louis to discontinue the making of loans on rice farms in Grand Prairie have adjusted themselves at this time so as to justify the resumption of its former policy of making loans, provided the security in each individual case is sufficient. It is, therefore, recommended that the present blanket restriction be lifted and that loans be granted upon the basis of individual appraisals made with care by especially qualified appraisers giving particular attention to the water supply available for each farm.

Because the drop in static levels in present wells has averaged almost 0.9 foot per year during the past five years, farms irrigated by shallow wells should receive loans only when the evidence shows that the prospective life of the water supply immediately beneath them is at least 15 years, and loans for longer periods should not be made until it is apparent that the general recession of the water table has been stopped or reversed.

The value of the protection afforded by small substantially-constructed storage reservoirs supplemented by wells should be recognized regardless of the absence of water rights, legal provision of which is not yet necessary because of the abundance of run-off. Similarly, farms irrigated by pumping from streams should not be discriminated against, nor should deep wells provided with non-corrosive screens; and the lower water-bearing stratum tapped by the latter should be considered as a valuable reserve supply for a somewhat larger area than is now watered by them.

Expansion of the present irrigated acreage depending on shallow wells should be discouraged until the drop in static levels is checked for several years in succession. Meanwhile the Bank should require the yearly curtailment of the rice acreage in each tract upon which it makes loans, to not more than one-half the cultivable acreage, and should support financially, if necessary, the systematic seasonal recording of water levels of at least 500 wells. If constitutionally-sound legislation can be secured to effect the general limitation of the rice acreage on each farm of the entire Prairie, it also should be urged.

Loans should be based upon conservative valuations averaging not more than $ 20 an acre, and should be permitted to exceed $ 25 an acre in exceptional cases only. Such systematic repayments of principal should be required as will keep pace with the possible progressive depletion of the water supply as conservatively calculated upon the basis of previous performance.

GENERAL FACTORS

Location and Description

The Grand Prairie is an area of about 600,000 acres in Southeastern Arkansas. Its approximate boundaries are Wattensaw Bayou on the north, White River on the east, Arkansas River on the south, and Bayou Meto on the west; thus it comprises the greater part of Arkansas County, the east-central part of Lonoke County, the southern half of Prairie County, and the small portion of Monroe County which is west of White River. The area with which this report has to deal in particular is somewhat more restricted than the area just described, and is delineated with exactness on Figure 1. The growing of rice is the principal industry of this area.

The present population of the Prairie consists largely of former residents of the Middle Western States, and includes many persons of German and Central European ancestry. The wide use of machinery characterizing the rice-growing industry and the corresponding low requirement for hand labor has resulted in a small negro population as compared with that of neighboring localities. The Prairie is well supplied with schools and the usual adjuncts of a modern farming community, including rural telephone and electrical service, the latter, because of the use of motors in pumping water from wells for irrigation, being available to many more farm homes than could have it otherwise.

Stuttgart is the largest city of the area, with a population of 4,927 (1930 Federal Census), and is its principal shipping and distributing point, but a half-dozen smaller centers are scattered over the Prairie area.

Rice Markets

Except in certain regions in the South, rice has never been a staple item in the American diet. Because production is concentrated in certain areas and because of its relatively low per capita consumption, the United States usually has a considerable quantity of rice available for shipment to non-contiguous territories and to export. The production of rice, which before the World War was insufficient for domestic requirements, was greatly stimulated by it. Low prices in the post-war period discouraged production, and the exportable surplus was much reduced; but in 1926 another large crop was raised and exports reached the level of five years previous. A peak of exports was reached in 1928-9, when 313,405,000 pounds of rice was sent to foreign markets.

The largest outlet for Southern rice, 1/ outside of the United States proper is in Puerto Rico, where the per capita consumption is 25 times the home consumption. As the island is a protected market, even in years when prices for rice in the United States are relatively high, that market will absorb a large quantity of American rice. In other markets in the Caribbean trading area the southern rice must meet the competition of rice from the Orient.

Other important markets for southern rice are in Europe and South America. In Europe the principal importers of American rice have been Great Britain, Germany, the Netherlands, and Belgium, but it has only been in years when the production in this country was large and the price low that any considerable quantity of American rice was imported by Europe. Outside of the Caribbean region and Europe the only important markets for southern-produced rice have been Argentina, Chile, and Canada.

California rice also finds its best overseas market in an American territory, in this case Hawaii. The California rice is of the Japan type, and the large number of Japanese living in Hawaii accounts largely for the heavy shipments to that market. As in the case of Puerto Rico, the Hawaiian market is a protected one, and American rice thus has an advantage over supplies from foreign sources.

Southern rice has a limited market in California, where the local type is not liked by many housewives. One of the authors of this report purchased choice Arkansas package rice in California a few days before taking up the detail here described. In fact, some apprehension was noted in Arkansas by reason of the recent introduction to California rice growers of seed of the varieties most favored in Arkansas, 2/ the apparent desire of California being to absorb some markets-at least here local ones-now supplied by southern growers.

1/ Louisiana, Texas, and Arkansas are the principal southern rice-producing states. In 1933 their respective acreages and production were as follows: Arkansas, 153,000 acres, 7,344,000 bushels; Louisiana, 369,000 acres, 14, 760,000 bushels; Texas, 141,000 acres, 7,473,000 bushels. California had 106,000 acres, and produced 6,042,000 bushels.

2/ Two varieties, Early Prolific and Blue Rose, constituted 94.4 per cent of the 1933 crop of Arkansas, the former variety alone accounting for nearly half the acreage. Although Early Prolific matures somewhat sooner than Blue Rose which is a distinct advantage in some seasons its quality is not so high and it sells for lower prices; hence in recent years Blue Rose has gained in the favor of many growers.

Table 1 shows the amounts of American rice exported since 1926. Notable in this table is the severe reduction appearing for the year 1932-3, which undoubtedly has had its reflection in the present large surplus in domestic mills and markets.

Table 1.- Exports of Rice from the United States, by Years, 1926-7 to 1932-3

Destination	Year						
	1926-7	1927-8	1928-9	1929-30	1930-1931	1931-32	1932-3
	1000 lbs.	1000 lbs.	1000 lbs.	1000 lbs.	1000 lbs.	1000 lbs.	1000 lbs.
Total	234,548	230,432	313,405	235,159	224,549	214,473	135,906
Europe	121,914	133,819	173,117	131,749	142,690	152,672	95,332
Other countries	112,634	96,613	140,288	103,410	81,859	61,801	40,574

By far the greater portion of Arkansas rice is marketed in continental United States, although a limited market is represented by Puerto Rico. Likewise, most shipments are made by rail or highway. Atlantic ports such as Philadelphia and New York receive heavy consignments in normal years, but the usual movement is to Mid-Western centers such as St. Louis, Kansas City and Chicago. Rail freight rates to the latter city is now 35 cents per hundred pounds- a considerably lower rate than the one current a few years ago. However, about as much rice leaves Stuttgart now by automobile truck, even to cities as far away as Milwaukee, as goes by rail. Apparently the price stabilizing operations of the Federal Government have removed former incentives of purchasers to buy in large quantities ahead of immediate needs, while discount savings and delivery to their doors have added to the desirability of the service offered by truck freighters.

Grand Prairie rice is marketed through eight mills located within the area. Two of these are operated by the Arkansas Rice Growers Cooperative Association. This agency at present handles nearly one-third of the crop, which is sold after being milled by the Association. A branch of the American Rice Growers Association also operates in the Prairie, acting essentially as a broker in marketing rough rice for its members. Both organizations offer a certain degree of protection to their members by reason of keeping them in touch with the trend of prices; and the former, by a rice-grading service, is especially helpful in establishing a bargaining basis for the farmers in the periodical sales conducted by the mills.

The marketing of what remained of the 1933 Arkansas crop was proceeding slowly on August 1st, and somewhat more than the usual surplus, both on farms and in mills was awaiting sale. Specifically, the carry-over was then estimated at 1,800,000 pockets 1/ of milled rice for the Nation, about one-third of which was in Arkansas. The Secretary of Agriculture later declared a rice surplus, and anticipated purchases of 500,000 pockets for relief agencies are expected to strengthen substantially the market for all grades of rice.

Rice must meet the competition of potatoes as well as grain foods with which most American families are more familiar, which puts it at a disadvantage in price control programs, especially when the severely reduced 1933 acreage and production are considered. Hence, some uncertainty exists regarding prices for the immediate future. In fact, preceding the declaration of the surplus, some liberalization of the stabilization policy was effected, which was expected to result in a freer marketing of the grain. The greatly reduced 1934 wheat and corn crops may sustain rice price levels or even improve them; however, it appears doubtful that materially higher prices could have other effect than reduced consumption. Improvement of foreign outlets effected through national bargaining operations or through the improved position of the American dollar in inter-national exchange has, so far as could be ascertained, still to make its appearance, but may show in future months.

1/ A pocket is 100 pounds of milled rice, the equivalent of approximately 3.6 bushels of rough rice

Transportation

Grand Prairie is well supplied with railroad transportation. (See Fig.1) The Chicago, Rock Island & Pacific line connecting Little Rock and Memphis crosses the northern part of the area, while the main line of the Cotton Belt railroad (St. Louis and Southwestern) traverses it from southwest to northeast, serving Stuttgart, which is one of its most important shipping points. A branch of this railroad extends from Stuttgart to Gillett. Limited passenger service is offered by both roads, but bus lines carry the bulk of such traffic.

Both White and Arkansas Rivers normally are navigable to points well above those contiguous to Grand Prairie, and some rice moves out of the area by water routes. Freight trucking over the public highways appears to be on the increase so far as the transportation of rice is involved. Stuttgart is connected with De Witt by an asphalt road, which in fact extends a few miles southward toward Gillett, being gravelled to that village. Well graded gravel roads also connect with England, whence a concrete road extends to Little Rock; and other stretches of hard surfaced road deviate from this and other centers. A badly-needed improvement under way when this report was being written was the grading of an unfinished stretch about ten miles long in the road running north from Stuttgart to Little Rock-Memphis highway.

Much desirable improvement remains to be effected on the main roads, and even more on the country roads, most of which are not gravelled and many not even graded. A reason contributing to the nominal amount of the expenditures which have been made on these roads is the apparent inability of the rice farms to support the heavy cost of modern highways; nevertheless, this section of the State is not so well off in this respect as other areas somewhat poorer and more isolated. In dry weather the country roads are passable though rough; but in wet weather considerable stretches of them are little short of impassable. In the matter of marketing farm produce, the Prairie would be distinctly at a disadvantage were it not the fact that its principal crop is either stored on the farms or moved from them before the fall rains set in.

Arkansas County ranks among the first of the State in the number of automobiles owned by farmers. It is notable that, despite their universal use, these cars are almost exclusively those of the lowest-price group.

Climate

The climate of Grand Prairie is humid, with long, hot summers and short winters. The mean annual temperature at Stuttgart is 62.6 degrees F. The mean temperature for the months of December, January, and February is 44.0 degrees F., for the summer months 79.3 degrees F., and for spring and fall 62.9 degrees F. and 63.6 degrees F., respectively. The lowest recorded temperature in winter is -10 degrees F. The humidity being high, the summer days seem sultry, and in winter, when the thermometer is around zero, the cold is felt more than in less humid regions. The climate and the water requirements of the rice crop together produce a mosquito infestation in summer months which is one of the area's most notorious disadvantages. The ground seldom freezes to a depth greater than 2 inches. Snowfall rarely exceeds 3 or 4 inches and usually melts in a few days. Some winters are mild, with no snow or freezing weather.

The mean annual precipitation is reported at Stuttgart as 51.01 inches, with a minimum of 40.22 inches in 1929 and a maximum of 69.13 inches in 1906. In the average year the fall months are the driest and the spring season is the wettest.

Table 2, compiled from the records of the Stuttgart Weather Bureau Station, gives the essential climatic data in detail by months and seasons:

Table 2, - Normal Monthly, Seasonal, and Annual Temperature and Precipitation at Stuttgart, Ark., (Elevation 228 feet).

	Temperature			Precipitation		
	Mean	Absolute Maximum	Absolute Minimum	Mean	Total Amount For Driest Year (1929)	Total Amount For Wettest Year (1906)
	°F	°F	°F	Inches	Inches	Inches
December	44.1	82	0	5.10	5.18	7.02
January	42.9	81	-10	5.02	5.10	6.76
February	45.2	84	-10	3.99	4.44	1.49
Winter	44.1	84	-10	14.11	14.55	15.59
March	53.8	92	14	5.49	2.72	5.31
April	65.2	92	26	4.98	5.32	2.68
May	69.8	98	33	4.79	2.07	5.19
Spring	62.9	98	14	15.26	10.11	13.88
June	78.0	107	44	3.87	3.46	8.32
July	81.2	112	53	3.80	1.58	7.03
August	80.6	102	47	3.53	0.50	5.04
Summer	79.3	112	44	11.20	5.54	20.39
September	75.1	109	35	3.27	1.93	8.61
October	63.3	97	23	3.10	4.05	3.13
November	52.4	86	10	4.07	3.87	7.85
Fall	63.6	109	10	10.44	9.85	19.59
Year	62.6	112	-10	51.01	40.22	69.13

The average date of the last killing frost in the spring at Stuttgart is March 25, and of the first in the fall, October 30. This gives an average growing season of 219 days. Summer precipitations in single storms of 24-hours duration during the past 30 years have been of the following frequency: June, 2. to 3 inches, 7 storms; 3 to 4 inches, 2; 4 to 5 inches, 2. July, 2 to 3 inches, 5; 3 to 4 inches, 4. August, 2 to 3 inches, 6; 3 to 4 inches, 1. The number of those storms precipitation 2 inches or more is shown in Table 3.

Table 3. - Number of Summer Rain Storms of 2-in. or more at Stuttgart, Ark., 1904 to 1933

Year	June		July		August	
	No.	Inches	No.	Inches	No.	Inches
1904	1	3.20	1	3.10	-	-
1905	1	3.38	-	-	-	-
1906	1	4.02	2	5.14	-	-
1907	-	-	1	2.01	-	-
1908	-	-	-	-	-	-
1909	-	-	-	-	-	-
1910	1	2.51	-	-	-	-
1911	-	-	-	-	-	-
1912	1	2.03	-	-	1	2.20
1913	-	-	1	3.04	1	2.81
1914	-	-	-	-	-	-
1915	3	6.54	-	-	1	3.12
1916	-	-	1	2.77	-	-
1917	-	-	-	-	-	-
1918	1	4.56	-	-	-	-
1919	-	-	-	-	1	2.58
1920	-	-	-	-	-	-
1921	-	-	-	-	1	2.23
1922	1	2.00	-	-	-	-
1923	-	-	-	-	-	-
1924	-	-	-	-	-	-
1925	-	-	-	-	-	-
1926	-	-	-	-	-	-
1927	1	2.05	-	-	-	-
1928	-	-	-	-	-	-
1929	-	-	-	-	-	-
1930	-	-	-	-	-	-
1931	-	-	-	-	-	-
1932	-	-	1	2.40	-	-
1933	-	-	2	6.56	2	4.62

Only one storm of 2 inches or more (2.33 inches) was reported in the summer months of 1934 through August 13, when this record closed. This occurred June 5 and 6. However, another storm on June 3 precipitated 1.33 inches.

The heaviest 24-hours precipitations during the complete years 1904 to 1933 are shown in Table 4, the heaviest storm of 2 inches or more being reported for each month.

Table 4.-- Heaviest 24-hr. Precipitations at Stuttgart, Ark.

Year	MONTH											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1904	-	-	-	-	-	3.20	3.10	-	-	-	-	3.0[illegible]
1905	-	-	3.21	2.00	4.44	3.38	-	-	-	2.10	-	-
1906	4.40	-	2.31	-	-	4.02	2.84	-	2.17	-	2.74	2.17
1907	2.50	-	-	-	3.33	-	2.01	-	-	-	2.29	-
1908	2.00	-	-	-	-	-	-	-	-	-	2.45	-
1909	-	2.47	-	-	3.02	-	-	-	2.37	-	-	-
1910	-	2.63	-	-	2.83	2.51*	-	-	-	-	-	-
1911	-	-	-	2.18	-	-	-	4.70	3.75	-	-	-
1912	-		3.41	3.16	-	2.03	-	2.20	-	2.07	-	-
1913	2.28	-	-	4.75	2.52	-	-	-	3.22	-	-	-
1914	-	-	-	-	2.30	-	3.04	2.81	3.65	-	2.50	-
1915	-	-	-	-	-	2.48	-	3.12	-	-	3.20	2.00
1916	-	2.04	-	2.61	-	-	2.77	-	-	2.85	-	3.74
1917	-	-	2.45	-	-	-	-	-	2.33	-	-	-
1918	-	-	-	3.12	-	4.56	-	-	2.11	-	-	-
1919	-	-	3.15	-	-	-	2.58	-	3.59	3.10	2.00	-
1920	2.50	-	2.07	2.25	-	-	-	-	-	2.20	-	2.33
1921	-	-	-	5.76	-	-	2.23	-	-	-	-	-
1922	2.15	-	2.76	-	-	2.00	-	-	-	-	-	-
1923	-	-	-	-	2.22	-	-	-	2.66	2.42	-	-
1924	-	-	-	2.30	-	-	-	-	-	-	-	-
1925	-	2.70	-	-	-	-	-	-	-	-	2.80	-
1926	2.68	2.01	2.40	-	-	-	-	-	-	2.93	-	3.62
1927	-	-	2.67	3.84	2.02	2.05	-	-	-	-	3.78	2.19
1928	-	-	-	3.07	-	-	-	-	-	4.26	-	-
1929	-	-	-	-	-	-	-	-	-	-	2.04	-
1930	3.27	2.77	-	-	3.14	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	4.15	2.28
1932	-	-	-	-	-	-	2.40	-	-	-	-	2.14
1933	-	-	2.60	-	2.70	-	3.36	2.45	-	-	-	4.00

Heaviest 24-hour precipitations in 1934, through Aug. 13, were as follows: March 2, 2.75 inches; March 26, 2.45 inches. Total monthly precipitation was as follows: January, 2.61 inches; February, 2.33 inches; March, 7.84 inches; April, 2.29 inches; May, 3.44 inches; June, 4.37 inches; July, 2.52 inches; August (through August 13) none.

Topography

The average elevation of the area is about 200 feet above sea level, the range being from about 230 feet in the northern portions to about 180 feet at southern points. The slope is therefore mostly southward, with a trend toward the east. Principal drainage channels, including White River and Bayou Meto, have this general direction of flow, and their tributaries within the Prairie conform to it. Both White River and Arkansas River are directly tributary to Mississippi River. The largest interior drainage channel is Bayou Lagrue, which flows into White River; to it is tributary Little Lagrue Bayou. The main tributary of Bayou Meto is Two Prairie Bayou, which drains the Lonoke County portion of the Prairie; other tributaries of Bayou Meto are Mill and King Bayous.

The topography of the area is, on the whole, extraordinarily uniform, ranging from nearly level to undulating and gently rolling. In the vicinity of Fairmount, Prairie County, some sections are quite rolling. On account of the even slope the drainage of much of the area is slow, necessitating the assistance of various artificial courses, especially in sections where rice-growing is predominant. (Pertinent aspects of these drainage developments are discussed elsewhere in this report.) There are, however, numerous shallow drainage ways extending throughout the rice-growing areas from a few hundred feet to several hundred yards wide, which act as drainage ways for large quantities of the surface water. These are locally termed "slashes". While they may hold considerable standing water for a long time during wet seasons, most of them have a sluggish flow and carry off considerable surplus surface water. These slashes form the heads of small streams, which find their way to larger streams in the lower, timbered country. There are few streams throughout the rice-growing areas, although there are large streams near by, which act as the drainage outlets for the prairie slashes.

Formerly the lands in the slashes and bottoms were valued chiefly for their timber and what they afforded by way of grazing advantages, but in recent years their possibilities of economical transformation into shallow water-storage reservoirs have been widely recognized, and several developments of this sort, described at another place in this report, have been made. The natural production of these lands is still timber, barrel staves being manufactured from the elm, oars from the ash, and various other articles from the other timber.

Throughout certain portions of the Prairie, notably its northern sections, are small mounds from 1 to 3 feet high and from 10 to 100 feet in diameter, which interfere somewhat with their adaptation to rice growing. Aside from these mounds, the generally uniform slopes of the Prairie are easily prepared for rice. Only a few hundred acres of Prairie land remain unbroken, so that the figure has little present or future significance, but the cost of preparing it for irrigation (including the cost of building farm ditches and their structures) was reported in the 1930 Federal Irrigation Census to have averaged $ 10.34 per acre. (The corresponding cost for the entire group of irrigation states was $ 28.21.)

Soil

The typical soil of the Grand Prairie is the Crowley silt loam, which exists in large contiguous areas in Arkansas, Prairie, and Lonoke Counties. The surface soil is a gray to brown-gray silt loam. In its original state, or where it has not been heavily cropped, it is fairly well supplied with organic matter.

The soil of the Crowley silt loam consists of about 10 inches of mottled light-brown to ashy-gray silt loam. When wet this soil is dark brown in color, but when dry it becomes quite gray. The subsoil from 10 inches to about 24 inches is a gray or a mottled gray and yellowsilt loam. Beneath this the subsoil to a depty of 36 inches is a heavy gray or mottled gray and yellow, or a red or mottled red and gray heavy silty clay. On the rolling and better drained areas of this type the subsoil from 10 to 24 inches is usually quite yellow in color, with only slight mottling. In these rolling areas the subsoil from 24 to 26 inches is usually mottled red and gray, while in the lower areas it is usually gray. In other words, where drainage is poor the gray color is predominant, while in the gently rolling areas the red and yellow colors are more often found.

The soil is friable and of excellent tilth. On some of the lower areas of the type where drainage is poor the soil dries out and bakes on the surface, and if not cultivated before drying it becomes so hard that cultivation is difficult. The lower subsoil is compact and very nearly impervious to water. Often a thin, compact layer of dry silt, light in color, is encountered just overlying this impervious subsoil. The lower silty clay subsoil is locally termed "hardpan", but it is not a true hardpan, as there is no true cementation of the soil particles. This peculiar impervious condition of the lower subsoil is probably due to the silt particles. In flat or poorly drained areas there are numerous small rounded iron concretions throughout the soil and subsoil.

The Crowley silt loam is strongly acid in its native condition, but this acidity is said to be somewhat ameliorated by the chloride content of the well water used in irrigation.

Crops

The importance of the different crops raised on Grand Prairie farms, relative to rice, is believed to be measured with fair accuracy by Table 5, which shows 53.6 per cent of the total area in rice, 22 per cent fallowed, and soy beans and oats together comprising about 12 per cent. The farms upon which Table 5 is based comprise a group upon which loans have been made by the Federal Land Bank.

Table 5. - Crops Grown on 40 Farms
in Grand Prairie, Ark.

	Grand Prairie (40 Farms)		Arkansas County (25 Farms)		Prairie County (5 Farms)		Lonoke County (10 Farms)	
	Acres	Percent	Acres	Percent	Acres	Precent	Acres	Percent
Total Area in Farms	10,890	-	7,171	-	1,227	-	2,492	-
Rice	5,831	53.6	3,757	52.3	689	56.4	1,385	55.0
Corn	322	3.0	288	4.1	26	2.1	8	0.4
Cotton	99	1.0	92	1.3	4	.03	3	0.2
Soy-beans	716	6.6	652	9.2	6	.04	58	2.4
Oats	604	5.6	533	7.4	26	2.1	45	1.7
Other Crops	312	3.0	77	1.1	90	7.3	145	6.1
Fallow	2,373	22.0	1,308	18.0	377	30.6	688	28.1
Timber	608	5.5	458	6.5	-	-	150	6.1
Waste	25	0.2	6	.07	19	1.5	-	-
Corn, Cotton, Soy-beans and Other Crops	2,053	19.2	1,642	23.1	152	11.57	259	10.8

The nearly universal practice in Grand Prairie is to grow rice two years successively on a field, then let the field "lie out", or "blank farm" it for two years, by which course the land is broken in May in time to kill the early weeds and grasses before they go to seed. Throughout the summer and until killing frosts in the autumn the fallowed field is worked over with tractor-drawn discs, to keep noxious seed from maturing, two to four discings being required according to the summer rainfall.

This practice is varied by some farmers by a "one year in and one out" rice rotation, and still others raise three crops of rice and fallow for two years. However, as would be assumed from Table 5, much of the land out of rice is put in other crops which, whether profitable or not themselves, effect a working over of the soil that serves much the same purpose as the "blank farming" practice.

The generally recognized necessity to rest the land between rice crops effects a control over the acreage devoted to rice which appears to prevent a future approach to the maximum acreage reached in 1926, when 161,000 acres was in the crop. New sod land planted to rice will raise, say, five successive crops before weeds and grasses become so noxious as to require a change. The rapid development of the industry reached its peak in 1925 or 1926, since when very little new sod has been broken, and the necessary rotations have now become so well established as to hold the maximum acreage well below that established in 1926, quite regardless of other influences.

Table 6 shows the rice acreage for Arkansas and for Grand Prairie by years since 1905, when production first reached commercial proportions; and for the same period, the production and farm price, per bushel. The crop curtailment program of 1934 was intended to effect a 20 per cent reduction of the 1933 acreage. Mid-July estimates indicated only an 11-per cent acreage cut, and an increase over 1933 of 4 bushels (52 bushels per acre) in yield, but severely reduced rainfall of the 1934 summer months necessitated extraordinarily heavy pumping, notwithstanding the acreage curtailment, and the condition of the crop for the State was estimated on August 10 as 80 per cent of the normal. This reduction has been attributed to insufficient water in certain areas.

Table 6. - Rice Acreage of Arkansas and Grand Prairie; Yield (State); Farm Price (State); and Value per Acre (State), by Years, 1905 to 1933.

Year	Area Harvested		Production (State)		Farm Price	Value
	State	Gr.Pr.	Per Ac.	Total	Per Bu.	Per ac.
	1000	Acres	Bushels	Bushels 1000	Cents	Dollars
1933	153	120	48.0	7,344	78	38.44
1932	163	122	51.0	8,313	37	18.87
1931	177	146	55.0	9,735	61	33.55
1930	172	141	47.5	8,170	78	37.05
1929 1/	156	127	51.0	7,956	94	47.94
1928	164	131	47.7	7,823	86	41.02
1927	175	144	44.0	7,700	90	39.60
1926	199	161	53.0	10,547	100	53.00
1925	175	142	43.0	7,525	150	69.30
1924 2/	164	130	42.0	6,888	138	58.93
1923	135	110	39.5	5,332	112	44.24
1922	154	123	48.0	7,392	88	42.24
1921	125	100	53.5	6,688	92	49.22
1920	175	145	49.0	8,575	131	64.19
1919 3/	158	126	39.0	6,162	240	110.40
1918	170	136	43.0	7,310	180	68.22
1917	146	117	41.0	5,994	190	77.90
1916	125	100	50.5	6,312	96	48.48
1915	100	80	48.4	4,840	95	45.98
1914	93	74	39.8	3,685	90	35.82
1913	105	84	36.0	3,769	90	32.40
1912	91	73	37.5	3,405	94	35.25
1911	72	57	39.0	2,792	82	31.98
1910	60	48	40.0	2,400	70	28.00
1909	28	28	40.0	1,120	90	36.00
1908	11	11	41.0	467	92	37.72
1907	6	6	37.0	222	85	31.45
1906	4	4	31.0	131	85	26.35
1905 4/	-	-	48.6	22	100	48.60

1/ 1929 Federal Census reported 146,588 acres, 6,958,105 bushels.

2/ 1924 Federal Census reported 166,249 acres.

3/ 1919 Federal Census reported 143,211 acres.

4/ Less than 500 acres.

Table 7 shows the areas of rice harvested in the Grand Prairie, by counties for the years 1929 to 1933. (See Figure 1 for the approximate location of the farms growing rice during that period or any of the five years.) The crop curtailment program of 1934 resulted in allotments by rice districts approximately as shown by Table 8 and on Figure 2. Figure 3 shows by yield ranges, the relative production of the lands throughout the Grand Prairie by way of averages for the five year or shorter period, as the individual case may be. Together the three figures present a picture of the relative performance of the various sections of the Prairie in rice production for the period. 1/

While the 1934 allotments assigned to the Prairie approximately 106,000 acres, it was reported after the irrigation season was well advanced, that some plantings had exceeded the acreage allotted. On the other hand, the almost total absence of summer rains tended to offset the relief to the irrigation water supply where the allotment was adhered to, and some acreage was said to be distressed. The preparation of this report was concluded before the full effects of these influences could be measured with assurance. Where the 1934 acreage is involved in their later computations the authors have, therefore, assumed that 110,000 acres was irrigated, from all sources, in Grand Prairie during 1934. Whether or not the drought or other causes resulted in the omission of some acres, allotted or unallotted, from the 1934 harvest, the fact is that the originally-planted total acreage was given water through practically the entire irrigation season.

1/ Neither table nor map is more than approximately accurate, because of various discrepancies and indefinite indications encountered when the data upon which they were based were assembled. The authors take full responsibility for these presentations, but caution the reader against assigning too great a degree of accuracy to them.

Table 7, - Areas of Rice Harvested in Grand Prairie by Counties, by Years, 1929 to 1933

Year	Grand Prairie	Arkansas County	Lonoke County	Monroe County	Prairie County
	Acres	Acres	Acres	Acres	Acres
1929	127,040	87,180	13,760	1/	26,100 1/
1930	140,960	93,400	15,880	2,080	29,600
1931	146,330	96,750	16,510	2,380	30,690
1932	126,769	80,995	15,192	1,990	28,592
1933	120,359	75,384	15,070	1,870	28,035
Average	132,292	86,742	15,282	2,080	28,603

1/ Monroe County acreage included in Prairie County figure.

Table 8. - 1934 Rice Crop Allotment Districts in Grand Prairie, Arkansas and Estimated Yields per Acre Based on the 5-year Period 1929-1933.

District	Area Allotted	Expected Yield	
		Total	Average
	Acres	Bu.	Bu.
No. 1	4,832	217,795	45.0
No. 2	6,537	315,404	48.2
No. 3	9,241	434,569	47.0
No. 4	10,023	468,889	46.7
No. 5	5,959	284,499	47.7
No. 6	7,068	336,085	47.7
No. 7	10,905	504,479	46.1
No. 8	6,994	308,428	44.1
No. 9	5,182	233,728	45.1
No. 10	2,320	95,107	41.0
No. 11	6,520	341,916	52.4
No. 12	7,497	381,390	51.0
No. 13	10,423	565,072	54.2
No. 14	12,571	583,910	46.5
Total, Grand Prairie	106,072	5,071,271	47.7

As is indicated by Table 6, the history of the Grand Prairie as a rice-producing section of importance began in 1905, when 460 acres of the grain were harvested. The following year's acreage was eight times as large, and ten years later 100,000 acres were devoted to the crop. Meanwhile, many thousands of acres which previously had its principal agricultural use as pasture and hay land had been sold at much higher prices than the few dollars an acre it previously was worth. A peak of 145,000 acres was reached in 1920, marking the height of the rice-growers' prosperity. That was the period of inflated prices which followed the World War. Few industries benefitted from it more than the rice-growers', and perhaps none felt more severely the immediately-following deflation. In 1919 the average farm price of rice, per bushel, reached $2.40; indeed, some farmers received even higher prices, and many whose fields were still new produced much higher yields than the average for the State. The average price in 1920 was much reduced, but the yield was better than that of 1919. With the breaking of the boom, however, many farmers met disaster, and the general effects of the distress which followed have not yet entirely disappeared. Nevertheless, after showing a reduction of almost 50 per cent in 1921, the acreage again began to increase, reaching its maximum in 1926, when 161,000 acres werein production. Never again were 1919 prices received, however; and when the average farm price sank to 37 cents in 1932 the industry once more was severely depressed. Rice was grown at a loss that year, but in 1933 the average farm price was more than double that received in 1932, and most farmers more than covered their expenses, which also had been substantially reduced.

Associated with their other troubles, the rice farmers suffered financially from failures of rice brokers and mills and from the banking disasters of the post-war and depression years. While a later discussion in this report indicates a partial correction of the indebtedness situation which these crises accentuated, both hard-times periods were especially calamitous to Grand Prairie farmers because of the heavy indebtedness they had built up in the purchase of their farms, the erection of farm buildings, the installation of pumping plants, and the many extravagances generally characteristic of the periods. Community indebtedness, while not so excessive as that of many other communities, played its part also by way especially of bonded drainage, levee, and road-improvement districts. (These are discussed in detail elsewhere.)

However, the most disturbing element of all was the performance of the underground storage from which came the water supply of most of the farms. Irrigation farming in Grand Prairie is distinctive from that in most other sections of the United States where water is applied to crops artificially, in that its irrigation service is almost entirely an enterprise of individual farmers. There are no irrigation districts nor farmers' cooperative companies, and the United States Government has no projects in the area. Thus the Federal Irrigation Census of 1930 showed that of the 151,787 acres in Arkansas irrigated the preceding year nearly 144,000 acres was irrigated by individuals and partnerships, the number of the latter being very few. The only other type of enterprise which supplies water is a loose sort of commercial company which sells or rents it, usually in exchange for a portion of the crop (commonly one-fourth in Grand Prairie), and while several pending plans may presently result in the large-scale provision of water on a sale or rental basis, its present retailing involves only a few farms in any particular case and not many in total.

This circumstance has doubtless been a fortunate one, for it has meant freedom from certain community burdens which have afflicted other irrigation sections; it nevertheless left the farmers without an agency which might have been effective in obtaining other water supplies when the decline of the water table suggested ultimate depletion. This threat began to occasion concern late in the 1920's, and led to the addressing of a request to the United States Geological Survey for an investigation which might determine the seriousness of the situation. Such a study was made by David G. Thompson, a member of the Survey's staff. A preliminary statement based upon the study which followed was issued by the Survey in 1931, showing that the decline of the water table had indeed proceeded at a rate which constituted a distinct threat to the permanence of a part of the supply of the Prairie area; and this report so alarmed the officials of the Federal Land Bank of St. Louis that they shortly afterward removed the entire Prairie from the territory in which the Bank would make farm loans. This action was followed by similar bans by other credit agencies, and the farmers presently found themselves cut off from all real estate credit sources save such of those agencies already holding mortgages, as were willing to refund them when they became due.

Meanwhile the general course of economic events led to a progressive reduction of the rice-growing area, and the periodic reading of certain representative wells, which had continued since the publication of the Geological Survey's report, appeared to indicate that some correction of the water situation was taking place. This was marked enough in the Autumn of 1933 to induce the Federal Land Bank to withdraw its restrictions from the Southern and Northwestern portions of the area (see Fig.4), but its unwillingness to lift the ban entirely led to further negotiations with the farmers, who contended that correction of the circumstances which led to the original restrictions had proceeded far enough so that the Bank could safely reenter the Prairie without qualification other than such as would apply to individual conditions. Their argument was supported by the conclusions reached by Dr. George C. Branner, State Geologist, who estimated on the basis of a study made under his direction in the Spring of 1934, that so long as the annual consumption does not increase substantially above 175,000 acre-feet, there will be little possibility of the exhaustion of the ground water supply.

The outcome of these negotiations was the ordering of the survey by the Bureau of Agricultural Engineering here described and as explained in full in the Introduction.

ECONOMIC CONDITIONS

While more and more consideration has been given, in recent years, to the possibilities of other crops, the growing of rice is still so preponderantly the leading agricultural industry of the Grand Prairie as to justify designation of the area as a one-crop section. As such, it has characteristics distinguishing it from the adjacent cotton farms or farms upon which diversified agriculture is practiced.

Some of these peculiarities are suggested by Federal Census Statistics. Table 9, assembled from various publications of the Fifteenth Decennial Census, shows pertinent statistics for farms irrigated in 1929 in the four counties comprising the Prairie, and like figures for the unirrigated farms of the same counties. Such of these as describe the sizes of the irrigated farms and their values will be discussed in later paragraphs. Here attention is directed first to the figures showing values of farm implements and machinery.

Rice farming in this area is distinctly a mechanized industry. Prevalence of anthrax disease discourages the extensive use of horses and mules (although they are used on a few farms), but regardless of this influence, the large and level fields and uncomplicated needs of preparing the land and of seeding and harvesting the crop, make the use of machine power economical in most of the farming operations.

Thus the value of implements and machinery is shown as $2,281 per farm and $6.54 per acre, compared with only $137 per farm and $2.54 per acre for the unirrigated farms; and since these are averages, it is obvious that for many farms the figures are much higher.

Likewise the values of buildings: On a per-acre basis, the rice farms show lower averages than the non-irrigated farms, but on a per-farm basis their averages are higher by far. In fact, the dwellings and other buildings, while now generally showing the need of repairs and paint, are distinctly superior to the corresponding improvements not only on Arkansas farms, but also on farms in many other localities. Most of these buildings, having been erected some years ago, are evidence of the severely contrasting prosperity of those times with that of today, especially as regards the rice industry.

Differing in one important respect from the farms of most one-crop sections, many farms of the Grand Prairie have home gardens and good ones. This is said to constitute a circumstance distinctly different from the habit of more prosperous days, when rice farmers considered that they could not afford to raise garden produce. Moreover, most farmers now keep chickens and a few hogs and cows. However, with respect to livestock generally, the statistics showing in Table 10 pertaining to farms classified in the 1930 Federal Census as "cash-grain" farms, which obviously for the Grand Prairie counties are almost exclusively the rice farms, still show approximately the true situation.

Also illuminating are the figures in Table 11, which show the value of the 1929 products of the cash-grain farms in the Grand Prairie Area.

Table 9 shows, by counties and for the entire Prairie area, the average size of the irrigated farms reported in the 1930 Federal Irrigation Census; also the corresponding averages for the unirrigated farms. The comparison is illuminating, especially as it discloses the extraordinarily large area of the irrigated farms (all of which are rice farms). Specifically, the average irrigated farm is 349 acres in extent, while the average unirrigated farm includes only 54 acres.

TABLE 9. - Number, Area, and Specified Farm Values of Irrigated and Unirrigated Farms in Counties Comprising Grand Prairie, Ark., 1930 and 1920, and Areas Irrigated, 1929 and 1919.

Item		Grand Prairie	Arkansas County	Lonoke County	Monroe County	Prairie County
Irrigated farms, 1930	number	841	546	86	20	189
1930	acres	293,416	186,624	32,477	8,175	66,140
1920	number	943	609	166	3	165
Size (average) 1930	acres	349	342	378	409	350
Area irrigated, total, 1929	acres	125,191	84,662	12,567	2,345	25,617
1919	acres	112,812	76,511	24,941	1,135	10,225
per farm, 1929	acres	149	155	146	117	136
1919	acres	120	126	150	378	62
Value of land, per farm, 1930	dollars	12,729	13,033	13,529	12,862	11,504
per acre, 1930	dollars	36.50	38.13	35.83	31.47	32.87
buildings, per farm, 1930	dollars	3,099	3,237	3,226	4,270	2,520
per acre, 1930	dollars	8.88	9.47	8.54	10.44	7.20
imp. & mach., per farm, 1930	dollars	2,231	2,169	1,936	3,459	2,559
per acre, 1930	dollars	6.54	6.64	5.12	8.46	7.31
Unirrigated farms, 1930	number	13,195	1,755	6,103	3,395	1,942
1920	number	12,261	1,178	5,430	3,302	2,351
Size (average), 1930	acres	54	74	47	43	76
Value of land, per farm, 1930	dollars	1,560	1,334	1,754	1,452	1,346
per acre, 1930	dollars	23.95	18.14	36.99	34.00	17.71
buildings, per farm, 1930	dollars	507	531	525	440	551
", per acre, 1930	dollars	9.42	7.22	11.06	10.30	7.25
imp. & mach., per farm 1930	dollars	137	149	145	113	141
per acre, 1930	dollars	2.54	2.03	3.05	2.71	1.85

Table 11.-Value of Farm products Sold, Traded, or Used by Operator's Family, for cash-grain Farms of Grand Prairie, Ark., 1929

Item	Grand Prairie: Farms reporting	Grand Prairie: value	Arkansas County: Farms reporting	Arkansas County: value	Lonoke County: Farms reporting	Lonoke County: value	Monroe County: Farms reporting	Monroe County: value	Prairie County: Farms reporting	Prairie County: value
	Number	Dollars	Number	Dollars	Number	Dollars	Number	Dollars	Number	Dollars
All products sold, etc.	854	6,015,697	551	4,079,764	94	498,762	24	100,107	185	1,337,064
Crops sold or traded	854	5,581,761	551	3,806,559	94	435,564	24	89,749	185	1,249,889
Livestock sold or traded	311	65,386	188	42,347	50	11,545	4	3,240	69	8,254
Livestock products sold or traded	625	177,235	402	109,573	69	28,358	7	771	147	38,533
Forest products sold or traded	56	10,701	42	5,606	6	630	1	3,702	7	763
Farm products used by operator's family	777	180,614	501	115,679	85	22,665	19	2,645	172	39,625

Irrigation Census figures permit no further breaking down of these averages, but other statistics from the 1930 General Farm Census offer such opportunity. Thus, Table 12 discloses with accuracy sufficient for the present interest, the relative importance of the various size group, the cash-grain classification being its basis.

Thus the model size is not much different from the average size (349 acres) since it is obviously included in the 260-499 acre group; the latter and the two next larger comprise nearly seven-tenths of the entire number of farms.

In an historical sense the characteristically large size of the rice farm is of interest as perhaps suggesting a cause of part of the financial troubles of the rice farmers. Again referring to the Irrigation Census figures (Table 9) it is seen that the number of farms actually declined between 1920 and 1930, although the total irrigated area increased moderately. In other words, the area of the average rice farm increased. The explanation of this development given the authors was that the profits from rice growing during and immediately after the World War induced many of the farmers to purchase adjoining farms; and some (like many other farmers elsewhere) let their ambition get the better of their judgment, incurring indebtedness based on war-time valuations which distresses them to this day.

Valid defence of the size of the farms lies, however, not only in the almost universal use of mechanical units in the major farming operations, of which mention has already been made but also in the necessary curtailment of the rice acreage involved in rotation requirements. Thus, the more or less general practice of keeping only one-half the cultivable area in rice is disclosed by the Census figures for 1929, which while showing 293,000 acres as the area of the irrigated farms, report only 43 per cent as actually irrigated that year. Allowance being made for uncultivated areas in homesteads, etc., this ratio appears to be what would be expected from the customary rotation.

Farm Mortgage Indebtedness

At the outset of their survey the authors were informed of a serious situation represented by outstanding indebtedness against real property comprising the rice farms. In their memorandum entitled "The Facts About The Rice Territory of Arkansas", submitted in the Spring of 1934 to the President of the United States by N. J. Rollison, Chairman, and Joseph Morrison, Secretary of a committee representing the Farmers Union, the following declaration appeared:

> "The farmers of the rice territory are in a desperate condition because for the past five years there have been no private agencies lending money. While no check has been made, informed persons estimate that 75% of the rice land of Arkansas is mortgaged or encumbered with some character of lien. As 90% of these liens were created originally more than five years ago during the heyday of prosperity, it will be seen that the rice farmer now is in a deplorable condition and is dependent entirely upon the grace of his creditors in permitting him to continue."

Table 12. - Cash-Grain Farms in Grand Prairie, Ark., By Size, 1930

Size Group	Grand Prairie	Arkansas County	Lonoke County	Monroe County	Prairie County
	Number	Number	Number	Number	Number
Total	854	551	94	24	185
Under 20 Acres	4	3	1	-	-
20 - 49 acres	31	15	4	7	5
50 - 99 acres	53	30	10	3	10
100 -174 acres	177	127	7	4	39
175 -259 acres	132	86	13	1	32
260 -499 acres	306	192	43	6	65
500 acres and over	151	98	16	3	34

Such a proportion of farm mortgage indebtedness as 75 per cent is so high as to be most unusual, but various local bankers and other usually well-informed authorities made even higher estimates, the highest being 90 per cent, this notwithstanding the ratio of 46.6 per cent reported for a 1927 survey of Arkansas rice farms made by the University of Arkansas 1/ and the similar 1930 Federal Census figures (which are representative of all farms, rather than merely those devoted to rice-growing), as follows: Arkansas County, 37.9 per cent; Lonoke County, 45.0 per cent; Monroe County, 41.5 per cent; Prairie County, 38.7 per cent.

Likewise disturbing was the more or less general complaint regarding interest rates reported to be charged on farm real estate mortgages, from which the impression was gathered that, by reason of commissions and fees charged on original first mortgages and on their periodic renewals, usually translated into second mortgages, the customary 6 per cent rate became an actual 8 or 10 per cent. Again such declarations were made by reputable authorities supposedly in position to know the facts, and notwithstanding Professor Hall's 1927 average of 6.9 per cent and the 1930 Federal Census averages 2/.

Accordingly, a special investigation which also included study of taxation, was undertaken to ascertain the present facts regarding farm mortgages. Two townships (T 3 S, 4 W, and T 3 S, 5 W), considered to be typical of the entire Prairie and inclusive of almost one-fourth the total number of its rice farms, were selected for the investigation, the details of which were handled by M. K. Boutwell, an experienced abstractor of Stuttgart. Mr. Boutwell listed the legal description of each farm, its total acreage, the names of its present owner and last previous owner, the date of the transfer by which present ownership was established, the consideration involved, the amount of the mortgage where one was of record, its maturity date, and the interest rate carried by the loan. From this search the following facts developed:

Eighty-three farms, or 41.1 per cent of the 202 rice farms had (in July, 1934) first mortgages on 20,833.28 acres or 48.5 per cent of their total area (42,946.45 acres). The total obligation represented was (as of record) \$ 765,234.97, or \$36.73 per acre. The annual interest obligation was \$ 47,009.69 or \$ 2.26 per acre. The average interest rate was 6.14 per cent.

Twenty-seven of these 83 farms had also second mortgages on 5,845.17 acres, totalling (as of record) \$ 58,647.17, or \$10.03 per acre. Annual interest obligation was \$ 4,508.52, or 77 cents per acre. Average interest rate was 7.5 per cent.

1/ "Rice Farming in Arkansas with Financial Results for 1927, "by Orville J. Hall, Arkansas Agricultural Experiment Station Bulletin No.260, page 21.

2/ The Census average for Arkansas County was 7.12 per cent. Farms operated by full owners owning no other farm land were involved, and the farms were not confined to those growing rice.

One of the 83 farms had also a third mortgage on 160 acres, for $ 1,050.00, or $ 6.56 per acre. Annual interest obligation was $ 105, or 66 cents per acre. Interest rate was 10 per cent.

Thus 41.1 per cent of the farms and 48.5 per cent of their total area are mortgaged. The average obligation is $ 39.60 per acre on the mortgaged acres. The average annual interest obligation is $2.48 per acre, and the average annual interest rate is 6.26 per cent. From these facts the authors reach the conclusion that the present proportions of farms and areas mortgaged are high, but by no means so high as popularly supposed. The present average interest rate is not extreme.

However, the average indebtedness, per acre, for acreage indebted, is out of line with present values, and even with what should be considered normal values. Good rice farms have recently sold substantially lower than the $39.60 average indebtedness reported. Obviously many of the loans were made when values ranged around $ 75 to $100 per acre. The onerous feature of the present mortgage situation is therefore not the average interest rate in itself, but the excessively large loans upon which it is assessed.

Although representing circumstances not greatly differing from those existent in many other agricultural communities, certain additional facts were developed by the mortgage study which partly explain the exaggerated popular belief regarding the present extent of real estate indebtedness. Thus of the 119 farms now free of debt, 16, comprising 3,028.77 acres, became so by the foreclosure route, and 31, comprising 6,547.14 acres, became so by deeds forestalling foreclosures. Thus, while four foreclosure suits now in progress prospectively will still further improve the statistics by relieving that number of farms and 700 acres of their present indebtedness, it may still be said that nearly two-thirds (64.4 per cent) of all the farms, and more than that fraction (70.9 per cent) of their area, are now or have been mortgaged.

A combination of these figures in accordance with the dates upon which transfers to presentownerships became effective is suggestive of the history of declining rice farm prosperity. Thus in the two Arkansas County townships, one forced deed was written in 1906 involving a quarter-section farm, but no foreclosure or deed in lieu of it was recorded thereafter until 1919, when an 80-acre farm changed hands by the forced-deed course. The record of later years was as follows: 1920, 2 farms (320 acres) deeded; 1921, 1 farm (160 acres) deeded; 1922, 1 farm (160 acres) deeded; 1923, 2 farms (612.28 acres) deeded; 1924, 2 farms (800 acres) deeded; 1925, part of 1 farm (320 acres) foreclosed; 1927, 2 farms (320 acres) foreclosed; 1928, 4 farms (329.09 acres) foreclosed and 3 farms (920 acres) deeded; 1929, 2 farms and part of another (626.27 acres) foreclosed, and 1 farm and part of another (210.92 acres) deeded; 1930, 3 farms (560 acres) deeded; 1931, 1 farm (320 acres) foreclosed and 3 farms (360 acres) deeded; 1932, 4 farms (713.01 acres) foreclosed and 7 farms and part of another farm (1720 acres) deeded; 1933, 1 farm (80 acres) foreclosed and 2 farms (323.94 acres) deeded; 1934, 1 farm (320 acres) foreclosed, 1 farm (160 acres) deeded, 4 farms (700 acres) in process of foreclosure.

Such representatives of loan agencies as could be reached conveniently were interviewed to ascertain the status of present mortgages. Dependable statistics were obtainable from several only, 1/ but the general effect of all data developed was that an appreciable proportion of mortgages (say perhaps one-third) were behind on their payments. Mortgage holders in Grand Prairie, as elsewhere, prefer to foreclose only as a last resort, and where the farmer appears to be doing what he can to pay out he is carried along in the hope that the arrival of easier circumstances may permit him to do so. It is possible also that the hope of the Federal Land Bank's re-entry into the lending field in the Prairie is inducing some postponement of foreclosures which might otherwise be effected, this hope being fostered by the possibility of a refunding of mortgages, with the Land Bank stepping into the shoes of the present mortgagees.

Moreover, it is apparently true that the present average mortgage interest rates are lower than those current a few years ago. While the Arkansas County search was not extended to the point of ascertaining exactly what previous rates and charges had been, it is believed that many of the transfers forced since, say, 1920, had been occasioned at least in part by rates somewhat in excess of those now common. During the period of the Prairie's most rapid development it was customary for loan agents' fees and commissions to be covered by second mortgages, which ran for such terms as meant the increase of the 6 per cent rate on first mortgages to 8 or 10 per cent on the money actually received by the borrower. Thus the non-appearance of the expected high rates in the Arkansas County study is perhaps merely evidence that the correction of the abuse has been accomplished largely by the drastic method of foreclosure or its equivalent.

Moreover, a voluntary correction has been made effective on a number of outstanding mortgages. Mr. Boutwell is authority for the statement that several mortgages on his list are really extensions of earlier mortgages, terms of which were somewhat more severe, reflecting again the willingness of some creditors to ease former mortgage burdens rather than acquire unwanted farms through foreclosure suits.

1/ Pertinent data were obtained from the Southwest Joint Stock Land Bank of Little Rock, which, although not loaning in Grand Prairie since 1928 for reasons growing out of its own financial circumstances, has now 42 loans outstanding on rice farms. Total area represented by these mortgages is 15,609 acres, and the total area subject to cultivation is 14,115 acres. The cultivable acreage of the farms is therefore 90 per cent of their entire area. The obligation ranges from $13.50 to $32.50 per acre on total acreage, and from $ 13.50 to $ 37.50 per acre on cultivable acreage; the corresponding averages are $24.20 and $26.75 per acre. The Bank has acquired title to only 1 farm, but has foreclosure suits in process against 9 farms totalling 3552 acres, with 3403 acres cultivable; the total amount involved in the original loans is $ 92,800, or $26.13 per acre (27.27 per cultivable acre).However, settlement of most of if not all these suits is expected without acquisition of titles, as the farms are considered to represent values substantially in excess of the obligations. While the Bank has had some trouble with delinquencies in about a dozen cases where second mortgages exist, partly by reason of the second-mortgagees stepping in ahead of it for the proceeds of the harvests, and considers that its interests have not had just protection in those cases at the hands of the local courts, the statement was nevertheless made to the authors that, in general, the rice loans in Grand Prairie are among the Bank's best equities, and their present status relatively good.

Extension of the average indebtedness developed in the study of the two Arkansas County townships to the entire area in Grand Prairie farms included in the 1930 Federal Irrigation Census (293,416 acres) would indicate a present total mortgage indebtedness of $ 5,635,357 against 142,307 acres, or about twice the amount justifiable under the price levels current when the Census was taken. It is notable, in fact, that the average per acre mortgage indebtedness of the farms studied in 1934 was greater than the 1930 average land value of the irrigated farms ($36.50 per acre), and not substantially below the average value of land and buildings ($45.38 per acre). Either Census figure appears to be in reasonable harmony with the outstanding Federal Farm loans in the Grand Prairie area, which average $20.05 per acre. (See Table 13.) Therefore, if 1930 values be considered to approximate a normal, refunding of present mortgages in the Grand Prairie would appear prospectively to involve a severe reduction of present amounts. In short, if $20.05 per acre were to represent the basis of a refunding of all the present mortgages, their total would be reduced to approximately $2,850,000.

Status of Federal Land Bank loans.-- Table 13, which is based upon a study made by the Federal Land Bank of St. Louis as of June 1,1934, shows the status of its loans and the loans made by the Land Bank Commissioner in the Grand Prairie area. While this record shows some delinquencies, it alone would not appear to justify the exclusion of any extensive portion of the Prairie as an undesirable loan area. In fact, in comparison with the experience of other mortgagees, the Bank has not fared badly, which, to the authors, indicates that if future LandBank loans are made, they should be based on conservative valuations such as are represented by the Bank's loans now outstanding.

Figure 4 shows the location of the farms upon which Bank and Commissioner loans have been made. On this map also appear the boundaries marking the northern and southern portions from which prior loan restrictions lately were raised. The central area, as indicated, is still excluded territory for both types of loans.

Other Indebtedness

In addition to farm mortgages, many rice farmers are heavily indebted by reason of loans secured by chattel mortgages and mortgages on their crops. Their heavy investment in implements and machinery has largely been financed on credit, while it is customary for them to borrow money against their crop anticipations in order to pay fuel or power bills and carry the routine expenditures of the planting, growing, and harvesting seasons.

No statistics are at hand to indicate the extent of the indebtedness incurred to finance machinery purchases, but it is probable that this amount is not as large as was the case a few years ago, both because of reduced prices for pumps and engines and for tractors and harvesting machinery, and because of the greater care and economy in their operation induced by recent hard times. To some degree real estate mortgages reflect indebtedness incurred for the purchase of equipment, but the extent of this element has not been determined.

Table 13. - Analysis of Loans Made by Federal Land Bank of St. Louis and Land Bank Commissioner in Grand Prairie Area, Arkansas, showing all loans within Grand Prairie Rice Region that are Considered "Rice Farm Loans".

		Grand Prairie	Arkansas County	Lonoke County	Monroe County	Prairie County
Total Land Bank and Commissioner Loans in Force						
Number		74	39	17	None	18
Amount	dollars	361,800	215,100	80,300	None	66,400
Area	acres	18,983.38	11,277.10	4,390.86		3,315.42
Federal Land Bank Loans In Force						
Number		69	38	14	None	17
Amount	dollars	353,000	213,800	73,300		65,900
Area	acres	17,563.88	11,007.60	3,280.86		3,275.42
Average per acre	dollars	20.05	19.40	22.30		20.10
Commissioner Loans In Force						
Number		5	1	3	None	1
Amount	dollars	8,800	1,300.	7,000		500
Area	acres	1,419.50	269.50	1,110		40
Average per acre	dollars	6.20	4.83	6.30		12.50
Loans in Foreclosure						
Number		2	2	None	None	None
Amount	dollars	4,900	4,900			
Area	acres	326	336			
Average per acre	dollars	14.60	14.60			
Loans in Real Estate-Sold						
Number		7	None	2	1	4
Amount	dollars	43,600		8,500	7,500	27,600
Area	acres	1,764		480	320	964
Real Estate Value	dollars	27,000		5,700	5,000	16,300
Real Estate Sold	dollars	29,900		7,700	5,000	17,200
Loss (face value)	dollars	13,700		800	2,500	10,400
Summary of Payment Delinquency						
Number of Payments		No. of Loans	No. of Loans	No. of Loans	No. of Loans	No. of Loans
1		12	9	-	None	3
2		4	2	1		1
3		3	2	1		-
4		1	1	-		-
5		1	-	-		1
6		1	-	-		1
Total Loans Delinquent		22	14	2		6

Loans on crops are believed to exceed $ 1,000,000, the estimated of a Stuttgart banker being $ 1,250,000 for the normal year. These loans formerly were made on the more or less universal basis of $20 per planted acre. Last year's averages for the Stuttgart Production Credit Association ranged from $10 to $15 per acre. In 1934 the average is more nearly $17.50 per acre, the increase being induced by the recent considerable rise in costs. For instance, fuel oil has advanced from 2.75 cents to 4 cents per gallon, and twine from 6 cents to 8 cents per pound. The general cost increase is stated to be about 30 per cent. Tractors using taxed fuel no longer get the former 6-cent refund.

A Stuttgart bank which does much of the crop-loan business claims to have taken no more than nominal losses, if any at all, even during the depression. The Production Credit Association is liquidating as a State agency, although continuing to make crop loans, and expects to pay out completely. When visited, its outstanding loans were about $225,000, which were expected to be increased to about $250,000. They then numbered 155, but the anticipated increase was expected to bring the total to 175. 1/

Many old notes written to finance equipment purchased 12 to 15 years ago have recently been cleared up. 2/ On the other hand, many new purchases of this sort cannot be postponed much longer, and some considerable financing will probably be necessary to permit them.

Non-Resident Ownerships

On the basis of the Arkansas County study, a substantial proportion of non-resident ownership of Prairie rice farms exists. Of the total number of farms, 29.2 per cent, and of the total area in them, 28.5 per cent, were so owned. Of the non-resident ownerships, 41 farms representing 8,177.32 acres or 66.9 per cent, were acquired by foreclosures or other forced deeds. Again, of the non-resident ownerships, only 22.0 per cent of the farms and 27.4 per cent of the area represented by them, were mortgaged. The mortgaged non-resident farm represented only 16.1 per cent of the total mortgage area.

If applied to the total area of Grand Prairie irrigated farms reported in the 1930 Irrigation Census, the average discussed above would show that 78,624 acres are held by non-resident owners.

Farm Tenure

A high degree of tenancy on the rice farms is probably reflective, in part, of the passage of many farms into the hands of former creditors, especially of the non-resident class. The 1930 Federal Census figures, though not disclosing the changes of the past four years, show that for the entire Grand Prairie, 43.9 per cent of the irrigated farms and 39.6 per cent of the land in them, were tenant-operated. Of the total value of land and buildings, 36.9 per cent was represented by tenant farms. (See Table 14)

1/ Loans made through the Association are at 5 per cent; other local loaning agencies charge 6 per cent. The rate some years ago was more or less commonly 8 per cent on both chattel and crop loans.

2/ One prominent equipment house reported the recent payment of the last of debts owed it since 1920, amounting then to $650,000.

Table 14. - Tenure of Operators of Irrigated Farms in Grand Prairie, Ark., 1930

Item		Grand Prairie	Arkansas County	Lonoke County	Monroe County	Prairie County
Irrigated farms	number	841	546	86	20	189
	acres	243,416	186,624	32,477	8,175	66,140
Average, per farm	acres	350	342	378	409	350
Value, land and buildings	dollars	13,317,249	8,883,259	1,440,950	342,650	2,650,390
Average, per acre	dollars	45.38	47.60	44.37	41.91	40.07
Operated by owners and managers	number	472	299	42	9	122
	acres	177,179	111,306	17,527	6,355	41,991
Average, per farm	acres	375.5	372.3	417.3	706.1	344.2
Value, land and buildings	dollars	8,409,744	5,596,444	853,670	255,480	1,699,150
Average, per acre	dollars	47.32	52.79	48.43	42.01	44.40
Operated by tenants	number	369	247	44	11	67
	acres	116,237	75,318	14,950	1,820	24,149
Average, per farm	acres	315.0	304.9	339.8	165.4	360.4
Value, land and buildings	dollars	4,907,505	3,286,815	582,280	87,170	951,240
Average, per acre	dollars	42.22	43.65	38.96	48.44	35.25

In one important sense, this ratio is more favorable than might be assumed at first, for in most other localities the tenant farms are the better, when judged by reported Census values. In Grand Prairie, the average 1930 value of land and buildings of the tenant farms was $42.22 per acre, whereas the comparable figure for farms operated by owners and managers was $47.32 per acre.

Most farm leases in the Grand Prairie area provide for a share-crop rental; some provide for cash payments, but they are relatively few. The usual arrangement is for the landlord to furnish land, pump (but not distribute) the water, and pay taxes; he divides with the tenant the cost of the rice seed. The tenant provides the necessary implements and machinery and labor, and divides the crop equally with the landlord. If other crops are raised on the land not in rice, the tenant is usually welcome to take them all, provided he stands the entire expense of their production; the landlord considers that his profit comes from the incidental cultivation given the land.

Some leases make various stipulations out of the ordinary, such, for instance, as to divide the cost of sacking the crop and hauling it to the mill, the latter applying especially where the hauling distance is considerable; and some impose upon the tenant all costs except taxes, the landlord's share then being one-fourth the crop.

Taxes

As in the case of mortgage indebtedness, some confusing variation in representations regarding taxation was encountered when the survey was started, as a result of which the special mortgage study in Arkansas County was extended to include a detailed examination of the current tax records. The following facts were developed by this examination:

The total tax assessed against 301 farms in the two townships (T 3 S, 4 W and T 3 S, 5 W) for general purposes (State, county, school), in the last assessment, was $ 13,120.48, or an average of 30.7 cents per acre against the 42,786.45 acres involved. The assessed valuation of these farms totalled $ 509,990.00, or $11.92 per acre. The ratio of the tax to assessed valuation was $2.57 per $100.

Assessed valuation is obviously far below actual value. Nominally it is 50 per cent, and some reputedly excellent rice farms have recently sold at $25 an acre--not far, that is, from this basis; but these have been distress sales, and the present ratio of assessed to true value is considered to run from one-fourth to one-third. In Arkansas County the nominal and practically universal assessed valuation of rice lands was $10 an acre in 1930; in 1932 the basis was $8, and the present basis is $6. Improvements, including pumping plants, are now assessed on a valuation also supposedly 50 per cent of the actual. In 1930 motor-operated plants were given valuations ranging from $500 to $750; the 1934 basis ranged from $400 to $600. Engine-operated plants were valued in 1930 around $1000, and in 1934, $750. Bottom dry-farm land has been valued on the same basis as rice land; but cut-over timber; and waste-land, valued at $4 an acre in 1930, is now valued at $2; and hill farming land has been correspondingly reduced from $6 to $3.

In Lonoke County rice lands are valued, for taxation purposes, at $7.50 per acre, as compared with a 1930 basis of $10. The County Assessor is authority for the statement that the present tax on rice farms averages 26 cents an acre not including the assessment on improvements which, if included, would bring the total to from 35 to 50 cents; also that the corresponding rate in 1929 was about 80 cents.

In Prairie County pumping plants are now valued, for taxation, at from $200 to $400, depending upon whether a motor or an engine is involved; motors as a rule represent substantially the lower investment.

In Arkansas County the total present rate for State and county needs is 14.2 mills; in Lonoke County, 16.7 mills; and in Prairie County, 16.2 mills. School district rates in Arkansas County range from 5 mills to 18 mills; in Prairie County, from 4 mills to 18 mills. The portion of Lonoke County included in the rice-growing prairie pays a school rate of 18 mills, which is the case also of much of the Prairie County rice area. In fact, the 18 mill rate appears to be generally prevalent, as the school assessment, throughout the area with which this report is involved, though some sections escape with a lower rate. The rice-growing portion of Lonoke County therefore is assessed for all purposes except those of special districts, at a total rate of 34.7 mills, much of the rice property in Prairie County has a total rate of 35.2 mills, and a large part of the Arkansas County area has a 32.2 mills basis.

In addition to general and school taxes, a considerable portion of Grand Prairie is taxed by special improvement (drainage and levee) districts. (See Page 45) The two townships in Arkansas County involved in the study already described include many farms in drainage districts. However, some of these are not now making assessments, and Mr. Boutwell's list therefore shows only one-fourth (75) of the 301 taxed farms to be now assessed for other than general and school purposes. These farms include 15,867.79 acres. The last improvement district tax assessed against them totalled $6,172.28, or 39.8 cents per acre. The general and school taxes assessed against the same farms totalled $5,082.28, so that the average tax for all purposes was 70.9 cents per acre. The ratio of total tax to assessed valuation was $5.66 per $100.

The per-acre tax of the 301 farms, including the improvement district taxes paid by only 75 of them, averaged 47.4 cents.

The average valuation per acre of land in the farms taxed by the improvement districts was $12.53; the corresponding valuation of the lands outside the special districts was $11.53.

The conclusion reached from the study of present taxation is that the average burden is neither relatively nor actually a heavy one. However, it is now substantially lighter than was the case some years ago; hence an effort was made to ascertain the status of tax delinquencies. The authors were very greatly assisted in this task through the courtesy of Dr. C. O. Brannen, Acting Dean of the College of Agriculture, University of Arkansas, under whose direction a compilation of tax delinquencies for the entire State had been made in the Spring of 1934, and who made available the portions of the data which applied to the Grand Prairie.

Before these data are presented it is pertinent to point out the fact that liberal relief to tax delinquents has lately been provided by enactments of the State Legislature. Thus, where general taxes (not the assessment of special districts) are delinquent for the years 1930, 1931, or 1932, by payment of one year's taxes the property-owner can redeem the land. Thus, if taxes for all three years are delinquent, by paying for 1930 only the owner can effect redemption; if 1931 and 1932, payment for 1931 will clear the title. If only 1932 is delinquent, payment is rewarded by waiver of the 10 per cent penalty (which also applied to the other cases). Taxpayers have until October 1, 1934 to take advantage of these privileges; hence the presentations here made may be improved in the next few weeks. October 15, 1934 is the final date for payment of current (1933) taxes to prevent their going delinquent.

Status of Delinquent Taxes.--Notwithstanding the relief to delinquent taxpayers mentioned in the preceding paragraph, the delinquencies in Grand Prairie have increased substantially during the past five years, and were not being fast reduced when the compilation supervisied by Dr. Brannen was closed (April, 1934). The former fact is brought out by the comparisons in Table 15. This table shows, first, the facts regarding delinquencies for the 1928-9 year, and immediately following (for the portion of each county in the rice-growing region) the corresponding figures for 1932-3, both sets of statistics representing the status existing January 1, 1934. The table does not show a complete record of delinquencies since 1928-9, as the figures for the years intervening up to 1932-3 are ignored; but the "grand" totals for the two years shown, incomplete as they are for the entire period, nevertheless involve a large acreage, although the amounts of the unpaid taxes do not appear disturbingly heavy.

Relative to the corresponding circumstances elsewhere in the State, the tax delinquency situation in Grand Prairie is fairly good. Figures 5 and 6 illustrate the statistical facts presented by Table 15. They are portions of maps of the entire State, prepared under the supervision of Dr. Brannen in the course of his state-wide study. In their proper position in the State maps, Figures 5 and 6 give a somewhat favorable impression regarding the relative position of the rice farms.

However, of principal importance in the presentations of both table and Grand Prairie maps (Figures 5 and 6) is the obvious fact that delinquencies in the payment of recent taxes are far more numerous than those representing the first year of the record. This is the fact which should cause greatest concern to those interested in the security established by the titles to property in Grand Prairie, and the one which ought to have the earliest possible corrective attention if the credit of the land is to be reestablished.

Table 15.--Tax Delinquencies in Grand Prairie Rice Region, Ark., by Areas Involved, for Tax Years 1928-9 and 1932-3, as of January 1, 1934. (See Figures 4 and 5.)

County	Year	Delinquent General Taxes			Delinquent Improvement District Taxes	
		Area	Valuation	Amount	Area	Amount
		Acres	Dollars	Dollars	Acres	Dollars
Lonoke	1928-9	4,554	44,265	1,484.53	2,622	867.13
	1932-3	14,719	99,300	3,361.16	6,883	1,942.76
Prairie	1928-9	4,777	44,335	1,154.97	480	58.08
	1932-3	17,155	132,410	4,112.20	3,507	963.54
Monroe	1928-9	20	100	3.57	none	none
	1932-3	1,252	7,275	241.41	none	none
Arkansas	1928-9	17,625	222,240	6,727.43	6,271	4,455.92
	1932-3	59,226	562,730	16,078.36	17,141	8,662.65
Total	1928-9	26,976	310,940	9,370.50	9,373	5,381.13
	1932-3	92,352	801,715	23,793.13	27,531	11,568.95
Grand Total		119,328	1,112,655	33,163.63	36,904	16,950.08
Status For Area in Which the Federal Land Bank does not make Loans						
Lonoke	1928-9	634	5,695	184.46	100	3.00
	1932-3	2,490	18,275	584.52	1,150	18.30
Prairie	1928-9	4,777	44,335	1,154.97	480	58.08
	1932-3	17,155	132,410	4,112.20	3,507	963.54
Monroe	1928-9	20	100	3.57	none	none
	1932-3	1,252	7,275	241.41	none	none
Arkansas	1928-9	15,054	200,750	6,010.73	4,753	2,034.69
	1932-3	44,847	453,510	12,834.04	12,293	4,846.03
Total	1928-9	20,485	250,880	7,353.73	5,333	2,095.77
	1932-3	65,744	611,470	17,772.17	16,950	5,827.87
Grand Total		86,229	862,350	25,125.90	22,283	7,923.64
Status for Area in which Federal Land Bank's Restriction has been Modified -						
Lonoke	1928-9	3,920	38,570	1,300.07	2,522	864.13
	1932-3	12,229	81,025	2,776.64	5,733	1,924.46
Arkansas	1928-9	2,571	21,490	716.70	1,518	2,421.23
	1932-3	14,379	109,220	3,244.32	4,848	3,816.62
Total	1928-9	6,491	60,060	2,016.77	4,040	3,285.36
	1932-3	26,608	190,245	6,020.96	10,581	5,741.08
Grand Total		33,099	250,305	8,037.73	14,621	9,026.44

Cost of Raising Rice

A substantial reduction in the cost of raising rice in Arkansas has taken place since the present hard times set in. The extent of this reduction is brought out by Table 16, for which the Department of Rural Economics and Sociology, University of Arkansas, is authority. This table compares average costs for 1932 with those ascertained to exist in 1927. The former appear to represent 1934 costs in some particulars, although too low in others. Cost of fuel oil is now higher than two years ago, but electrical current is cheaper; the cost of water is still probably fairly close to the $6.75 per acre reported for 1932. As is shown elsewhere, taxes now average about 40 cents an acre less than in that year. Interest paid is about 40 cents more than the figure shown, and the cost of twine has increased a little.

On the basis of 1930 census valuations of buildings and machinery, which have previously been discussed, the overhead interest is too low by a substantial margin.

In general, the opinion of the authors is that 1934 costs of production total not less than 60 cents, and may be as much as 70 cents a bushel.

Table 16. - Cost of Producing Rice Per Acre and Per Bushel, 1927 and 1932. 1/ Department of Rural Economics and Sociology, University of Arkansas

Item of cost	1927	1932
	Dollars	Dollars
Cost per acre		
Labor and power:		
Man Labor (25.10 hours)	10.04	4.39
Tractor power	3.52	2.45
Horsework (10.60 hours)	1.87	1.06
Total	15.43	7.90
Water for irrigation (5 gals. per minute for 70 to 80 days)	10.55	6.75
Cash expenses other than for tractor and pump fuel, feed, repairs and hired services:		
Seed (2 to 2 1/2 bushels per acre)	2.94	1.69
Taxes	1.04	.90
Automobile	.97	.70
Interest paid	.87	.87
Insurance	.27	.25
Twine (4 pounds)	.60	.32
Miscellaneous	.60	.50
Total	7.38	5.23
Overhead:		
Interest on buildings, feed, supplies, land, cattle and poultry, and miscellaneous farm machinery	7.00	4.67
Depreciation of buildings, miscellaneous farm machinery, cattle, and poultry	2.03	1.35
Rent value and net change in inventory of dwelling used by hired labor	.10	.10
	9.13	6.12
Grand Total Per Acre	42.49	26.00
Total Cost Per Bushel	.80	.49

1/ Costs for 1927 are from survey data collected in 1928. The 1932 cost figures used 1927 inputs with 1932 cost rates. In order to have similar values for comparative purposes the same yields are assumed in 1932 as were found in 1927.

In the preceding discussion of taxes, mention was made of the assessments of special improvement districts, as well as school districts. A variety of funded obligations of such districts exists, constituting a factor which, although reflected in the tax rates already discussed, needs further explanation in connection with a consideration of the general financial situation of Grand Prairie as a community.

County Bonds

Monroe and Lonoke Counties have no bonds outstanding, although the latter levies a 1.5 mills tax for its "Court House fund", the court house having been built with the proceeds of the sale of post-dated county warrants. Arkansas County's 1/2 mill county bond assessment is on account of outstanding bonds reported to amount to $85,000, on which there is no delinquency. Prairie County also levied a 1/2 mill tax to support outstanding bonds amounting to $20,000, on which no default of either interest or maturities exists.

Road Improvement Districts

When the survey here reported was being concluded, the State of Arkansas was nearing the completion of a program by which some $146,000,000 of highway, toll-bridge, and road-improvement district bonds were to be refunded. Of this amount $47,142,075 represented the obligations of many road-improvement districts, a considerable number of which were located in the Grand Prairie. These issues were made between 1917 and 1921. Much disconnected road construction resulted, costs (representing the War and post-war periods) were high, and with the general agricultural slump of 1920-21 many of the districts faced default.

This situation resulted in 1927 in the passage by the State Legislature, of the Martineau Act, by the terms of which the State assumed the obligations of the districts. The latter, except where necessary to clear up delinquencies accumulated prior to the State's assumption, thereupon ceased to levy taxes on their account. However, no State bonds were issued to replace the district bonds, which remained outstanding with their original terms unchanged. In a strictly technical and legal sense, therefore, the improvement district bonds remained at least potential obligations of the localities which had sold them.

The 1934 refunding involves such an exchange. When this sentence was written (August 20), nearly half of the $47,000,000 bonds had been deposited with the State, to be exchanged for the latter's 3 per cent bonds. (The district bonds bore 5 and 6 per cent.) Some $12,000,000 of additional bonds, held by St. Louis bankers, were expected to be proffered for exchange, and opposition had appeared from only one holder of considerable amount (some $3,000,000, issued by districts in or near

Little Rock), so that there appeared little doubt that the plan would be successful. Once the exchanges were made, no obligation would exist against the districts, since the credit of the State would specifically replace that of the originally-bonded districts.

The new bonds will be issued as of January 1, 1934, and will mature January 1, 1949, but in the interim purchases will be made to effect their retirement, according to amounts accumulating in a sinking fund established by the ("Act No. 11"), approved February 12, 1934 by which the whole plan was established.

The belief of the authors is that the road improvement bonds issued in Grand Prairie need not be considered as local obligations, as their exchange for the State's refunding bonds may possibly take place before this report reaches the Administration for which it was prepared.

School District Bonds

Some difficulty was experienced in ascertaining the amounts and status of these issues, and of the areas obligated, partly because of the many consolidations which have recently been effected, the exact delineation of the new boundaries not appearing on records accessible to the authors. However, the following listings as of July 1, 1933, appear to disclose with approximate accuracy, the extent of these bonds for the Grand Prairie districts.

Monroe County:

NONE

Prairie County:

Hazen district	\$31,500 of 5 per cent bonds
Devall's Bluff district	89,000 of 5 1/2 and 6 per cent bonds
Ulm district	14,000 of 5 1/2 per cent bonds

Lonoke County:

Carlisle district	\$51,000 of 5 and 5 1/2 per cent bonds
Lonoke district	6,000 of 6 per cent bonds

Arkansas County:

DeWitt district No. 1	\$10,100 of 6 per cent bonds
Brough district No. 2	2,450 of ? per cent bonds
Stuttgart district No. 22	\$125,000 of $4\frac{3}{4}$ per cent bonds
Hagler district No. 27	3,874 of ? per cent bonds
Almyra district No. 53	21,000 of 5 and 6 per cent bonds
St. Charles district No. 54	10,900 of 6 per cent bonds
Gillett district No. 66	18,950 of 6 per cent bonds
New Providence district No. 69	3,939 of ? per cent bonds
Brewer district No. 71	6,015 of 6 per cent bonds

Of these issues those of the Carlisle, Lonoke, St. Charles, and New Providence districts showed no reduction during the year with which the record (in State Department of Education) was concerned.

All the districts listed, except perhaps Stuttgart, serve farming communities.

Drainage and Levee Districts

The need and character of drainage in Grand Prairie was referred to briefly in the description of its topography.

Although the natural drainage condition of the Prairie region is generally good, the construction of a large number of relatively small drainage ditches has effected the quick removal of surface water which otherwise would require much time for natural escape. This improved surface-drainage condition has been of great advantage in the rice-growing region, especially during the seasons of planting and harvesting.

Very few of the ditches in this area are seriously affected by large growth such as willows or cottonwood, the most objectionable channel growth being flag, smart weeds, water grass, or cat-tails. The side slopes of the channels are generally well stabilized. Very few channels are affected by silting, which is due to the strong resistance to erosion of the type of soil in this area.

Recently a large number of the drainage ditches in this area were cleared and cleaned. This work was performed by labor furnished by Federal Relief agencies. As this work was generally done along those reaches of ditch which were badly in need of repair, the greatest benefit was derived therefrom.

The authors consider that the drainage of the Grand Prairie is generally adequate for the satisfactory removal of the surface waters and for the successful farming of the land in this area.

Financial Status of Districts.- Likewise (in severe contrast with conditions in many other sections) the financial condition of the districts by which the drains were built is generally very good. The notable exception to this statement is Farelly Lake Levee District (an extensive enterprise serving areas in Jefferson County as well as Arkansas County). Present delinquencies are few and of inconsequential amounts. The exact facts are set out in Table 17. The location of the districts is shown on Figure 7.

In the opinion of the authors, the financial status of none of the drainage districts in Grand Prairie is such as to constitute a reason why the lands involved should be considered poor credit risks. This is not true as regards Farelly Lake Levee District. This enterprise has had a history notorious throughout southeastern Arkansas. It has been in default on the obligations represented by its bonds for several years.

In July, 1934, the Reconstruction Finance Corporation, in passing upon the district's application for a loan of $ 1,072,000 with which to refund its outstanding bonds and defaulted interest (on the basis of 50 cents on the dollar), authorized a loan of only $412,500. The bondholders have not assented to this settlement, and the authors are without information to indicate whether or not they are likely to do so. Until this or some other refunding shall place the financial affairs of the District in such shape as to indicate that they can be supported, the authors would consider the lands to constitute a dubious risk, and would not recommend that loans be made upon them, regardless of other perhaps more favorable circumstances.

Arkansas and Louisiana are the only States where irrigation is widely practiced, which do not have legalized systems of water rights. In this respect, as regards the development of water from pumped wells, they are no different from the other irrigation States except New Mexico and Oregon, both of which have undertaken by law to regulate the diversion of underground water.

While this circumstance appears to the authors to represent a much more serious situation than that represented by the absence of water rights laws governing the diversion for irrigation (or any other purpose) of the surface waters of the Grand Prairie, the inability of users of such surface waters to obtain legally-recognized rights has been cited as a reason for disregarding the security represented by supplemental supplies provided by various small surface-storage reservoirs the construction and usefulness of which are described fully in the next section of this report. The authors believe this matter has been given an importance which is not deserved, for the principal reason that the systems of surface water rights established by the Western States were necessitated by a scarcity of water not logically to be associated with the 50-inch annual rainfall of Grand Prairie. The underground supply of the Prairie is undeniably limited; but of the surface supply there is generally an abundance, rather than a scarcity.

It is conceivable that a succession of storage developments on some of the smaller water courses, or in fact, of any well-defined run-off area (for some of the reservoirs are filled by run-off from fields and not from well-defined drainage courses), will some day expand beyond the capacity of their sources to fill them all, but even that more or less remote possibility does not appear to demand the early enactment of surface water rights legislation nor to endanger the rights of irrigators who have already built such reservoirs or who plan to build them during the next few years; for it is believed that such diversions, when beneficial use of the water can be established, will stand before the courts of Arkansas in the preferred position recognized by the courts of Western States for the similar diversions made there in early days.

Apparently there are no local decisions so that any conclusion reached from this discussion must be by analogy only. The authors are confident that when and as an irrigation code is adopted in Arkansas, the position of present appropriators will be determined by their original acts and by proof of beneficial use, as against each other. Until there shall be some legal authorization to divert water, the present appropriators are trespassers and their rights are inchoate; but in the far West such early acts of trespass were later confirmed by law. This may or may not happen in Arkansas, depending upon future legislatures; until it does happen, the only thing the present appropriators can do is to continue their beneficial use so long as they are not enjoined by riparian owners. If and when an irrigation code is adopted, there will be little question that these present appropriators will be protected as against later appropriators.

As against riparian owners, the appropriators are trespassers and may be enjoined at any time. Arkansas is a riparian state. The only legal title they can establish is by prescription, which means, according to Kinney, "the continued, open notorious, exclusive, uninterrupted, and adverse use and enjoyment of the waters, and under a claim of right, for at least the period of time prescribed by the statute of the State where the right is claimed for the commencement of actions for the recovery of real property". Under this definition, whatever length of time the Arkansas statute of limitation prescribes for real property will apply to water rights.

It should be emphasized that (1) appropriators of water in Arkansas can acquire no title as against riparian owners until they shall have perfected a prescriptive right; (2) even if an irrigation code is adopted in Arkansas, appropriators can acquire no legal title as against riparian owners until they shall have acquired prescriptive rights: (3) while there is no predicting the course which the courts of Arkansas will take when the question of water rights comes before them, it is quite possible that they may follow the New York lead and require proof of actual damage to riparian lands, rather than the Western lead which will base an injunction on constructive damage. As Arkansas is a State containing large areas of wet land, actual damage to riparians will be correspondingly difficult to prove.

Another point on prescriptive rights acquired against riparian owners may be cited with pertinence. The California courts have held that an appropriator may acquire a prescriptive right against lower riparian lands, inasmuch as he is cutting off part of the water supply of those lands; but not as against upper riparian lands, for the water is going by those lands and the riparian can reach out and take it at any time but is not required to take it to keep his riparian right alive, hence is not being injured.

Possible Enactment of an Irrigation Code

Several efforts have been made in recent years to obtain the enactment by the Arkansas legislature, of an irrigation code which would establish, among other things, a system of water rights. Opposition to such a movement has come from citizens of Grand Prairie itself; but it has also come from other sections of the State, which fear the effect of water laws set up for one relatively small section, upon their own freedom of use. For example, several populous cities divert for domestic use the waters of conveniently accessible streams, Such diversions, some of which represent costly investments, are not protected by water rights nor by special legislation, and the cities enjoying present use of the diverted water, as well as others expecting to make such diversions, apparently wish to invite no complications by setting up regulatory laws. The authors doubt, therefore, that enactment of an irrigation code may be expected soon, and they are not impressed with the need for such early enactment. Development of surface storage has a long way to go before regulatory laws will be needed, unless they be such as will effect proper drainage in connection with the irrigation diversions.

Nevertheless, the control of further drafts upon the underground supply deserves the careful attention of the State's legislators, and even more, of the people of Grand Prairie, whose proper concern over the dependability of their underground water ought to extend much further than merely convincing the Federal Land Bank that it may safely loan in the Prairie. If by no other means than by legislative control can the further depletion of the well-supply be stopped, then such means should be taken, for until the other sources of irrigation water are developed far beyond their present capacity, the wells will continue to be the prime dependence of the rice industry, and whatever the possibilities of other crops, rice undoubtedly for some years to come, will be the agricultural mainstay of the Prairie.

Water for irrigation in Grand Prairie is obtained from both surface and underground sources. Without reference to their relative degress of importance, these are as follows: (1) by pumping from streams: (2) by storage of surface run-off in small reservoirs usually constructed by throwing levees around wooded depressions or by damming water courses; (3) by pumping from deep wells; (4) by pumping from shallow wells.

These present sources and others which possibly may be made available, are described and discussed in detail in the following paragraphs:

Pumping from Streams

There are three rather large and several small pumping plants in the Grand Prairie which secure their water direct from streams.

The largest of these plants is located at Crocketts Bluff on White River, where two centrifugal pumps are driven by steam engines. The combined capacity of the pumps is approximately 20,000 g. p. m. There is also an auxiliary plant of about 4,000 g.p.m. capacity driven by a heavy-duty oil engine, but this has not been in use for a number of years. The average lift of water is about 50 feet.

At one time, 4,000 acres were irrigated from this plant, but this maximum acreage has not been attained for several years. At present about 1,400 acres are being irrigated. This plant was first operated about 20 years ago.

There are two large plants pumping direct from Bayou Meto. One plant is located near Red Bluff, west of Gillett. It was built in 1911. The pumps are driven by steam engines, but can readily be connected to a 200 H. P. electric motor. When these plants were visited the lift appeared to be 35 to 40 feet as Bayou Meto was at very low stage; the estimated flow is 12,000 to 15,000 g.p.m. The area now irrigated is approximately 1,300 acres. The second of these plants, built in 1910, is located near Bayou Meto and is very similar to the first plant. The pumps are operated by steam engines, but a 200 H. P. electric motor is available. The lift appeared to be 35 to 40 feet. The acreage irrigated is estimated at 1,200. The average annual cost of operating these plants is estimated to be $ 6.00 per acre. Across the mouth of King Bayou is a small dam which holds some stored water that can, if needed, be released into Bayou Meto and pumped by these plants. On several occasions temporary pumps have been installed at the flood gate of the Farelly Lake Levee District and water pumped from the Arkansas River into Bayou Meto to supplement the supply for these plants. This recourse was adopted in 1930 and again in 1934.

There are a number of other small plants pumping direct from Bayou Meto, but it is estimated that not more than 1,000 acres are irrigated by all of them. Two small plants which formerly pumped from White River are not now in operation. Nearly 5,000 acres are now irrigated by direct pumping from streams. The locations of these plants are shown on Figure 8.

The authors consider that no large expansion of the area irrigated by direct pumping from local streams is likely to take place. The War Department will not permit any further diversion of the low water flow of the White River on account of navigation requirements.

Storage in Small Reservoirs

The economy of small local reservoirs as a source of irrigation water has not been fully appreciated until the past few years. Figure 8 shows the approximate locations of existing reservoirs, and those which probably will be constructed within the next few years.

In appraising the present and prospective development of such reservoirs the authors visited all but a few of the sites and in each case made inquiry of the owner, as far as possible, as to the size, cost, and acreage irrigated or to be irrigated.

The average rice acreage on the Grand Prairie since 1916 has been approximately 130,000 acres; of this amount about 10,000 acres are now watered from sources other than shallow wells. The inflow of water into the shallow-well sands or recharge is estimated to be sufficient to water about 100,000 acres. Hence it is seen that if this development is continued to the point that 20,000 more acres can be irrigated from reservoirs, the average drop in the wells will probably be arrested. Indeed, it seems highly probably that the lower costs of reservoir water are such that this development will soon proceed to the point where the drop in wells is not only arrested, but reversed. An individual or company by building such a reservoir not only procures a cheaper water supply, but contributes to the conservation of the underground supply on which his neighbors may depend.

The John Voss reservoir constructed 28 years ago near Crocketts Bluff, probably represented the first attempt to irrigate rice from a reservoir. This reservoir was formed by building a rather high dam across a ravine or draw. The water collected is pumped out by a 4,000 g.p.m. pump electrically driven. The lift varies from 4 to 14 feet. The average annual cost of power has been $2.00 per acre irrigated. The area within the high water line of the reservoir is about 200 acres, and the maximum depth of the water is 22 feet. It is estimated that about 280 acres was irrigated in 1933, and 210 acres in 1934.

While the dam is rather high and the slopes steep, no serious trouble seems to have been encountered in maintaining the dam. It was originally protected from wave wash by willows, but it was feared that the roots might penetrate too deeply into the dam, so the growth was cut and a plank breakwater installed. The cost of constructing this dam is not known to the authors,,but doubtless was small. The direct cost of power is about one-fourth that common for wells on the Prairie a few years ago.

There are a few other reservoirs in the rice area formed by building dams across draws or bayous, but the more common practice is to inclose an area entirely by dykes.

The Tyndall reservoir, in Sections 23 and 26, T 3S, R 5W, is the oldest reservoir entirely inclosed by dykes. This reservoir has been in use for eight irrigation seasons. It covers 450 acres of flat timbered land.

The average depth of water when the reservoir is full is approximately 5 feet, and water has been held to within one foot of the top of the dykes without trouble. The trees within the diked area, though long since dead, are still standing, but the smaller limbs have fallen off. Water is collected from adjacent areas.

In constructing the levees a small muck ditch was first opened and the dykes then built with a drag line. The original slopes were probably 1 to 1, but now appear to be somewhat flatter. The top width is not over 3 feet. The dykes now are well sodded with Bermuda grass and no serious effect appears to have resulted from wave washing. The old tree trunks will remain for a number of years longer and largely prevent erosion from wave action. Before they are gone willows can be planted as a protection against wave action. The Crowley silt loam used in building these dykes is a very resistant material, and when well compacted permits almost no seepage.

The water to be stored is pumped into the reservoir. About half the irrigated acreage served by the reservoir is watered by gravity; the water for the other half is pumped, the same pumps being used for both pumping in and pumping out. There are two pumping plants, each of 5,000 g. p. m. capacity. The average static lift is 4 to 5 feet. Each plant is driven by a 40 H. P. Twin City tractor-type gasoline engine, which is belt-connected to a 15-inch Aurora pump. It is estimated that each plant operated an average of 45 days per year in filling the reservoir. The average cost of fuel and lubricating oil per year is estimated at $ 1,000, or approximately $1.25 per acre served. The cost of operating a single engine for 24 hours is about $5.

The exact cross-section of the levee is not known, but the height will approximate 6.5 feet, the top width 3 feet, and the slopes something less than 1 1/2 to 1. On the basis of these dimensions the volume would approximate 16,000 cubic yards per mile and total about 56,000 yards for the 3 1/2 miles of levees.

The following estimate of cost of the Tyndall storage is based on the above data and probable contract prices.

Embankment, 56,000 cubic yards @ 20¢	=	$11,200
Two pumping plants @ $2,000	=	4,000
Land used, 450 acres @ $10	=	4,500
Cleaning right-of-way, 35 acres @ $60	=	2,100
Total	=	21,800

As the average area served is about 850 acres the investment per acre is about $ 26. A rough estimate of total annual costs per acre, including fixed charges, is as follows:

Interest on investment @ 6 per cent	=	$ 1,308
Annual depreciation charged on plants	=	300
Fuel and lubricating oil	=	1,000
Maintenance, ins. and taxes(estimated)	=	290
Total annual costs	=	$ 2,898

It is here assumed that after the levees became compacted and covered with Bermuda grass, the depreciation and maintenance charges were inconsequential. On the basis of the above estimate the total annual cost of irrigating 850 acres of land is approximately $3.40 per acre. This is an exceptionally low cost and probably few reservoirs could be constructed and operated so cheaply; but certainly a large number of reservoirs can be built which can supply water at less than $5.00 per acre served.

The water supply for this reservoir is secured from the rainfall on approximately 1200 1/ acres of adjacent lands. It is estimated that, when the irrigation season begins, there is an average depth of water in the reservoir of 5 feet.

The water stored has been sufficient to irrigate 800 to 900 acres of rice 80 per cent of the time, so that the area irrigated is about twice that of the reservoir. Once or twice a little additional amount of water has been supplied by pumps. If an allowance of one foot in depth is made for evaporation and seepage it appears that an average of 2 acre feet has been used to irrigate each acre of rice.

According to the experience of the owners of this reservoir, rice irrigated by stored water produces a better yield than that irrigated from wells. The reason for this is not clear. Possibly the decayed vegetable matter in the stored water has a beneficial effect on rice. It should also be noted that where stored water is used for irrigation a large flow can be used and the fields quickly covered, while with a small pump a considerable time is required to supply the same quantity of water. This is a considerable advantage when a field is drained and reflooded during a dry spell.

As stated in Bulletin No. 261, from 27 to 30 inches of water is sufficient to raise a rice crop. These figures include rainfall so far as it supplies water which otherwise would have to be pumped. The summer rainfall at Stuttgart averages 11.20 inches. During the past 47 years it has varied from 20.39 inches in 1906 to 2.56 inches in 1930. For 5 years it has been below 6 inches and for 2 years below 3 inches. The amount of pumping saved by rainfall depends not only on the quantity, but also on the distribution of the rains. Probably a rain in excess of 2 inches in 24 hours is not of much value in decreasing the amount of water pumped, and a very heavy storm is often a detriment. The summer rainfalls for the past 47 years are shown in Table 21, page 72.

From these data it is estimated that a reservoir located adjacent to the lands to be irrigated should have a storage capacity sufficient to supply 2 acre feet to each acre served.

The records at the Rice Branch Experiment Station indicate that the evaporation from a reservoir surface will average approximately 0.20 inch per day during the summer months, or a total of 18 inches. Reducing this by 6 inches of direct rainfall into the reservoir will leave a net loss of 12 inches, consequently at the start of irrigation, there should be an additional foot of depth of water in the reservoir to offset this loss.

1/ This estimate was made by Mr. Vern Tindall, after careful consideration, but one engineer has estimated the drainage area to be 1600 acres.

During the past 44 years the annual rainfall at Stuttgart has averaged 51 inches and has varied from approximately 40 to 69 inches. The winter rainfall is approximately 14 inches and spring average 15 inches. It is estimated that 12 inches of the annual rainfall, even in dry years, can be collected from a drainage area and stored in a reservoir. The experience of the Tyndall reservoir indicates that this estimate is conservative. The ditches, of course, should be well arranged to collect the water, so that practically all the run-off can be diverted to the pumps.

Assuming a farm of 320 acres to be irrigated from a 160-acre reservoir surrounded by dykes 7 feet high with a 3 foot top width and 2 to 1 slopes, the investment and the annual cost of irrigation are roughly estimated as follows:

Embankment 46,600 cubic yards @ 20¢	=	$ 9,320
Pumping plant, engine and 5,000 gallon pump	=	2,800
Land used, 160 acre @ $10	=	1,600
Cleaning right-of-way, 20 acres @ $60	=	1,200
Total original cost	=	$14,920
Interest on investment @ 6 per cent	=	895
Annual depreciation charge on plant	=	150
Fuel and lubricating oil @ $1.50 per acre	=	480
Maintenance, insurance and taxes	=	110
Total annual cost		1,635

According to the above calculation the cost of irrigating a half section of land from a small reservoir will approximate $5 per acre. In Bulletin 261,1/ annual cost of pumping was estimated at $10 to $ 12 for conditions existing in 1928 and 1929. The electric rates now in force will reduce costs about $2.00 per acre for motor-driven plants.

It is thus seen that the present tendency to build small reservoirs rests on a sound economic foundation. The larger the area enclosed, the less the costs of dykes per acre. The cost of dykes for a reservoir of 640 acres is about twice that of a 160-acre reservoir, while the area enclosed is four times as great. Probably the economic depth of storage is about 5 feet. In the case of a 160-acre reservoir holding 5 feet of water, the storage capacity is 800 acre feet. If it were desired to build a reservoir to store 1120 acre feet, it would be much cheaper to dyke an area of 224 acres to hold 5 feet of water, than an area of 160 acres to hold 7 feet of water.

The feasibility of taking a rather level farm of, say, 320 acres, and using alternately each half as a temporary reservoir from which to irrigate the other, has been suggested. Some farmers now summer-fallow or "blank farm" one half of their rice acreage in preparation for replanting to rice. The more usual practice is to grow dry crops for two years out of each four in preparation for a return to rice.

1/ Bulletin No. 261, Arkansas Agricultural Experiment Station, "Cost of Pumping and Duty of Water for Rice on the Grand Prairie of Arkansas".

If such a farm were dyked with levees 5 feet high, 3 feet top width, and 2-to-1 slopes, the embankments would amount to 44,500 cubic yards. In such a case no charge should be made for the land covered, as the flooding would replace the dry or blank farming. A rough estimate follows:

Embankment 44,500 cubic yards @ 20¢	=	$ 8,900
Pumping plant 5,000 gallons capacity	=	2,800
Total		$11,700
Investment per acre irrigated		$ 73

The annual cost per acre irrigated including operation, maintenance, and fixed charges, would be approximately $7.50, or less than the cost of irrigating from wells. The experience at the Tyndall reservoir indicates that the drainage area from which water is stored should exceed the irrigated acreage by at least 50 per cent. Thus if the run-off from some additional lands can be secured the water supply would seem sufficient. In a wet fall the pumps could be used to drain the land, which is sometimes quite necessary. The plan seems feasible, but should first be tried out on a small acreage to determine whether it is entirely practical.

There are now 18 completed reservoirs on the Grand Prairie with a total estimated capacity sufficient to water approximately 4,000 acres. These vary in area served from 40 to 900 acres. In addition to these several new reservoirs are now being considered. These will have a sufficient capacity to water 7,000 acres more, and it is probable that most of them will be constructed within the next few years.

In order to protect each reservoir owner in his right to store water it has been urged that the State enact a law providing for the adjudication of such rights. The authors believe that early enactment of such a law would be premature and that such action should not be taken until its necessity is more apparent. Experience will then be the best guide in shaping its provisions to make them helpfully applicable to Grand Prairie conditions. This subject has been more fully discussed in another section of this report. (See "Water Rights, " page 49).

The development of small reservoirs should be encouraged both as a means of securing cheaper water and of conserving the shallow-well supply.

Possible Storage in Large Reservoirs

Several plans for irrigating extensive acreages in the Grand Prairie from large reservoirs have been studied. The promoters of these plans propose to sell water to the farmers for a portion of the rice grown. On a basis of one-fourth of the crop, an average yield of 44 bushel per acre, and an average price of 90 cents the charge per acre would be $ 9.90. As the farms which it is proposed to serve are now irrigated from wells, the problem of inducing the owners to dispose of their pumping plants when the new water supply is made available should be given serious consideration.

Greers Ferry Project.- The largest of these proposed developments is one which would take water from the Little Red River near Greers Ferry. 1/

1/ A discussion of and estimate for this project are contained in "White River, Missouri and Arkansas," Document No. 73rd. Congress, 1st Session.

This project would consist of a dam and reservoir sufficient to store 400,000 acre feet above the canal outlet, a main canal 107 miles long ending near Fairmont, and a local distributing system. It would be a gravity project to irrigate 125,000 acres at an estimated total cost of $69 per acre. The capacity of the canal would be sufficient to deliver 1,200 c. f. s. This would be approximately sufficient if the demand for water were uniformly distributed through the irrigating season, but during long dry spells it is probable that nearly all the 125,000 acres would want water at the same time. If this were the case the demand would amount to approximately 1 second foot per 80 acres or a total of 1,560 second feet. Such a canal should be able to deliver at least 1,500 second feet for the acreage specified.

The average annual cost of irrigation, including operation, maintenance and interest is estimated to be $4.50 per acre. The estimated cost includes 5% interest on the investment. If it were possible to finance the project with private capital, the interest rate would be at least 6 per cent. It is also probable that the operation and maintenance charges would be greater than the amount estimated. This plan seems to be practicable, in some respects, but as water can be cheaply supplied from small local reservoirs, it is not probable that such a large project could be promoted under present conditions.

If the acreage served is 125,000, it would have to include nearly all the rice farms in the Grand Prairie. In 1934 there were about 1,000 operating wells; of these 25 per cent were pumped by electric power and 75 per cent by oil engines. The cost of fuel oil, lubricating oil and labor for heavy duty engine plants will probably average $4.00 per acre per year, and while it would be more economical if all other costs were included, for farmers to use the canal water, it is probable that many would continue to use their old plants until the well, pump or engine failed them.

The large expenditure necessarily involved in building a project such as the Greers Ferry scheme can be justified only on the basis of service to practically the entire irrigable area of Grand Prairie; hence its proponents have had in mind the formation of an irrigation district patterned on the lines of the districts numerous in Western States, which have bonding and taxing powers; It is assumed that such a district could compel the acceptance of its service even by irrigators unwilling to abandon their present pumping plants.

The authors consider this assumption faulty, for even if enough property-owners could be mustered to vote into existence such an extensive district as would be needed, there are so many with wells which have long life prospectively remaining, that many property-owners would be released from the district by the courts. In short, there is no way apparent by which acceptance of such service can be compelled. It might be induced if rates could be made irresistably lower than present costs of pumping; but the pumping costs entering into the competition would be only those covering actual operation, and would not include those involved in capitalization and depreciation. The estimated $4.50 per acre annual cost of the Greers Ferry plan will offer, it is true, an apparently profitable exchange for many farmers, but whether or not it is attractive enough to induce all the farmers to surrender their present independent position is questionable. So long as their present supplies give promise of holding out the farmers are in an advantageous bargaining position in dealing with projects which propose the substitution of other service, and such substitution on any widespread scale should not be expected until the

present water supplies are much nearer exhaustion than they are at present.

In addition to these considerations the financing of such a project would be difficult. Certainly there would be no market for the bonds of such a district today, unless it might be some one of the Federal emergency agencies. Even prospective sale to so supposedly an easy creditor as the Federal Government would not, the authoirs believe, make an irrigation bonding plan acceptable to the voters of Grand Prairie at present or for a long while to come, and for this and the other reasons already stressed they do not consider the Greers Ferry plan likely to become effective, although they recognize its engineering feasibility.

Farmers Water and Irrigation Company Project.- A large reservoir is planned by the Farmers Water and Irrigation Company. The location of this is shown on Figure 9 and the distributing ditches and area to be irrigated are shown on Figure 10. The project is divided into two units. The reservoir is to cover 16,600 acres located in the bottoms of Bayou Meto and Two Prairie Bayou. The storage capacity is to be 100,000 acre feet, which is a sufficient amount to irrigate 40,000 acres.

Two pumping plants are planned, one to have a capacity of 100,000 g.p.m. and the other 210,000 g.p.m. The pumps are to be driven by electric power at an estimated cost of 1.5 cents per K.W.H. The average static lifts at Plants Nos. 1 and 2 will approximate 36 feet and 27 feet respectively.

The estimated costs are based on a total of 80 per cent of the maximum acreage in the area involved, or 32,000acres. The operating costs exclusive of power but including depreciation and taxes are estimated at \$42,300 or \$1.32 per acre. The power cost is estimated at \$1.52 per acre, making a total annual cost of \$2.84 per acre served, or \$90,880 for the 32,000 acres.

It is proposed to supply water to the farms in return for 1/4 the crop. On a basis of 44 bushel per acre, a total area served of 32,000 acres, and a price of 89 cents per bushel, the gross income would be \$313,280 and net income \$222,400. This would be a net return of approximately 14 per cent on the estimated investment of \$ 1,566,000. If the charge for water were reduced to \$6.00 per acre the return would be about 6-1/2 per cent.

The present plan is to build unit No. 1 first and, if this proves profitable, later to add unit No. 2. The estimated cost of unit No. 1 is \$ 538,500. The annual cost of power is estimated at \$1.70 per acre, and assuming that the other operating costs would be the same as those for the combined units, or \$1.32 per acre, the total would be \$3.02. This unit could irrigate 15,000 acres, and on the above basis of 89 cents per bushel would yield a gross return of \$146,850. Deducting the total operating costs of \$ 45,300 would leave a net return of \$101,550 or nearly 19 per cent on the investment.

If the charge for water were \$5.00 per acre the gross income would be \$75,000 and the net return \$29,700 or approximately 5 1/2 per cent on the investment.

This project appears to be well planned and if constructed will supply water to a portion of the Prairie where the drop in well levels, during the past five years, has been the greatest. It may be difficult in some cases to induce farmers to abandon their old plants and use the reservoir water, but this will depend on the price asked.

Should the project be built and 15,000 acres water, the demand on the shallow-well sands will be reduced to approximately the estimated recharge.

This project has been under examination by the Public Works Administration for several months, and construction of it may be made possible by funds supplied by that agency. No allotment to it had been announced, however, when preparation of this report was concluded.

Other Proposed Projects.- Besides the projects mentioned there are several others for which some preliminary estimates have been made.

One of them proposes to build a large canal from a point near De Valls Bluff to North Little Rock and incidentally supply irrigation water to the Grand Prairie. Details of this scheme are not available, but the plan does not seem practicable as an irrigation project, and it is not probable that it will be constructed.

There are possibilities of building reservoirs between the west bank of White River and the rise to the level of the Grand Prairie. The water to fill these could probably be supplied from the prairie run-off. The pumping lifts would be 35 to 40 feet. It is probable that the cost of such projects would be about the sames as that of the Farmers Water and Irrigation Company previously described.

Ground Water of Grand Prairie

The Grand Prairie is underlaid with two distinct layers of horizons of waterbearing sands. The upper sands provide the water for the shallow wells from which probably 90 per cent of the rice acreage is now irrigated. The lower sands provide the supply for the deep wells, only a few of which are now in operation.

The shallow well sands are included in the upper layer of deposits known geologically as the Pleistocene beds; beneath these are the Tertiary clay deposits. An examination of a half dozen cross-section of the region, prepared by George C. Branner, State Geologist, indicates that the bottom of the Pleistocene or shallow well sands varies from about 0 to 110 feet above sea level; and that the average thickness is about 75 feet. The finer sands are near the top and the coarser sands near the bottom of this stratum.

The Tertiary clay beneath these sands and extending from the Ozark hills to Crowleys Ridge, was once the bottom of an ancient flood plain of the Mississippi River. During past geological ages the river shifted its channel from place to place over this area and deposited beds of sands and gravel of various degrees of fineness, according to the transporting velocities of the water. As a result of the erosive action of the water, this clay bed is cut into ridges and depressions, which accounts for the great variations in the depth of wells.

In later geological times these sands were covered with a sedimentary clay deposit which in the Grand Prairie region prevents direct percolation into the sands beneath. This bed of water-bearing sand extends westward toward the Osark hills and eastward towards Crowley's Ridge and it is probable that most of the water beneath the Grand Prairie seeps into the sand stratum from these outside areas. The velocity of water passing through such beds of sand is very slow and varies with the grade or slope of the pressure plane and the fineness of the deposits.

It is evident that the amount of water which can be safely pumped annually from this water-bearing stratum depends on the amount of inflow or recharge. As stated in the Thompson report, 1/ the annual amount of water pumped from the shallow wells has probably exceeded the recharge for every year since 1916 with the probable exception of 1921 and 1923. This has resulted in dewatering or partially exhausting the sands under certain areas, as shown on Plate I of that report. If this overdraught were long continued the more shallow wells would ultimately fail. The question of recharge will be discussed in a later paragraph (See "Pumping From Shallow Wells".)

According to the Federal Census of 1930, there were 913 active wells in the Grand Prairie during the Summer of 1929. The average area served per well was approximately 130 acres. The average depth of shallow wells is about 140 feet and the average depth of water in the spring of 1934 was 76 feet.

It is estimated that the average discharge per well is approximately 750 g.p.m., and varies between a few hundred gallons and as much as 4,000 gallons. The average drawdown per well is between 30 and 35 feet. The irrigation season usually covers 90 to 100 days from start to finish of pumping. The total time that a pump operates varies with the rainfall, the variety of rice grown, and the capacity of pump in relation to the acreage served. A pump of large capacity per acre served will supply the needed water in a shorter length of time than one of low capacity, but if electric power is used the cost of power per acre will be larger in the former case. The average time of operation of pumps has been estimated at 70 days of 24 hours each.

The average life of a well is estimated as 10 years. A few wells are now in operation which were dug 20 years or more ago. The necessity for digging new wells arises from corroding and failure of screens, by caving caused by pumping large amounts of sand, and by lowering of the static level to a point below the pump bowls, thus making it necessary to prime before starting. The average life of a pump is about 15 years. The average life of the old style heavy-duty diesel engine is probably 18 to 20 years. The average life of the more recent high speed engines is a matter of question as they have been in operation only a few seasons. The average life of a motor is probably 20 years.

1/ The 1931 press release issued by the United States Geological Survey.

See "History and Organization", page 24.

The investment in electrically driven pumping plants in 1929 varied from about $25 to $30 per acre served. Present costs are somewhat lower. Pumping plants operated by the old type semi-diesel engines represented an investment of probably $45 to $55 per acre served in 1929. None of these has been installed in recent years; a new type of high speed engine is now coming into use. The present investment in plants driven by these new semi-diesel engines will probably average about $30 per acre served, while plants operated by the tractor-type gasoline engine will average somewhat lower. As normally about half the farm is planted in rice the investment per acre for the entire farm will be about half the above figures.

Pumping From Deep Wells

There are 9 active deep wells in the Grand Prairie. The locations of these are shown on Figure 8. Some of them are over 10 years old. The last one was drilled in 1930. The deep wells obtain water from the Tertiary water-bearing sands, which constitute an entirely different stratum from that which supplies the shallow wells. As stated in the Thompson report, logs of a few wells indicate these sands to be 90 to 150 feet thick, but data as to the depths and water capacity of this stratum are very meager.

The depths of these wells range from 440 to 900 feet and the yield varies from probably 900 to more than 2,000 g.p.m. The drop in 5 deep wells for the 4-year period 1929 to 1933 varied from 0.10 to 4.20 feet and averaged 2.45 feet.

One of the most typical of the deep wells is on the Spicer farm. (The installation is fully described in Bulletin No. 261, previously referred to.) The well was completed in 1927 to a depth of 897 feet. The pit is 26 inches in diameter and 163 feet deep. The well casing is 10 inches in diameter and is surrounded with a gravel wall. The screen is made of chrome-nickle steel and is 150 feet long and 10 inches in diameter. The well cost about $10 per foot of depth and the cost of the plant complete was $16,400.

The static water level in May, 1929, was 35.6 feet below the surface; in the Spring of 1934 it had fallen 3.5 feet to a depth of 39.1 feet. This was an average drop of 0.7 foot per year. However, during the year ending in the Spring of 1934 the level rose 0.7 foot. The pumping level in the Summer of 1929 was 118.8 feet below the ground surface. The drawdown was thus 80.8 feet, and as the average flow of the well by weir measurment was 2,038 g.p.m., the specific capacity of the sands was approximately 25 gallons per foot of drawdown. During that season, this well yielded 747 acre feet of water and irrigated 402 acres of rice, at a total cost, including fixed charges, of $8.88 per acre, which was about 70 per cent of the corresponding average costs for shallow wells involving about the same static lift.

The temperature of the water from the deep wells is about 75 degrees, or 10 degrees warmer than that from the shallow wells. Ordinary screens do not last long in the deep wells, probably because of the carbon dioxide in the water; but the use of stainless steel has eliminated this trouble.

The 9 deep wells now operating probably have a total capacity sufficient to irrigate 2,000 acres of rice. While the safe yeild of the Tertiary sands is not known, it is probable that quite a number of additional wells could be drilled without exceeding the recharge of this stratum. Fifty deep wells yielding 1,800 g.p.m. each could irrigate 16,000 acres.

The cost of drilling deep wells has been reduced considerably in recent years by an under-reaming process whereby the well is made of smaller diameter in the portion above the sands. A deep well 800 feet deep, with a pump and motor sufficient to discharge 900 g.p.m. and irrigate 160 acres would cost about \$ 8,150.00. The approximate costs of the parts are as follows:- well \$6,400.00; motor and connections \$500.00; pump \$1,200.00; and building \$50.00. The probable life of the parts are as follows:- well 20 years; motor 18 years; pump 15 years; and building 15 years. The drawdown would be about 36 feet and the static lift about 80 feet.

The total annual cost of operation calculated on the same basis as that used in Bulletin 261 would be approximately \$ 1,674.00 or a little over \$ 10.00 per acre served. The fixed charges are based on 6 per cent for the invested capital and 4% on the sinking fund to cover depreciation. The present power charge would average about 1.6 cents per K.W.H. The overall plant efficiency is assumed to be 60 per cent and the time of operation 70 days.

It is thus seen that the total cost irrigating with such a deep well is about the same as that with a shallow well. The extra cost of the well is largely offset by the saving in power due to the lesser static lift.

If the yield were 1,800 gallons and the area irrigated 300 acres, the investment would be approximately \$ 9,000, or \$ 30.00 per acre. At present power rates the total cost of irrigation, including fixed charges, would average about \$ 9.00 per acre annually. It is not probable that a deep well would be drilled on a farm irrigating less than 240 acres, but should there be a failure of the shallow well supply beneath a farm irrigating 160 acres, and the price of rice return to its 25-year average of about \$ 1.00 a bushel, such a deep well would be an economic investment.

If the shallow wells on several adjoining small farms should fail, the owners could drill a single deep well and divide the water according to acreage.

The Tertiary sands contain a reserve supply of water which certainly will be more largely utilized if the levels in the shallow wells continue to fall. Records should be kept on all deep wells in order better to determine the reliability of this reserve supply.

Pumping from Shallow Wells

The annual rate of recharge is a most important factor in any consideration of the shallow well supply. In the Thompson report it was estimated that the annual amount pumped exceeded the recharge for every year following 1916, except 1921 and 1923. From available well logs and static water levels it was estimated that the total amount of water removed from the previously saturated sands was 333,000 acre feet. The area thus drained in which a water table now exists is shown on Plate I of the Thompson report. This over-draught or draining of the sands occurred over a period of 13 years from 1917 to 1929 and averaged about 25,600 cubic feet per year for the period. However, as stated by Mr. Thompson, the data on which this estimate was based were quite limited and the actual total volume of the over draught may vary materially from the figure given.

The average area irrigated on the Grand Prairie during these 13 years was approximately 130,000 acres. It is estimated that an average of 6,000 acres received water from other sources such as deep wells, streams and reservoirs, leaving 124,000 acres as the average area irrigated from shallow wells. The average summer rainfall at Stuttgart for this 13-year period was 9.50 inches and the average amount pumped during this period is estimated at 1.55 acre feet per acre. The 333,000 acre feet withdrawn from this underground reservoir on a basis of 1.55 acre feet per acre would water 214,000 acres, or an average of 16,500 acres per year for the 13-year period. Thus it appears that of the 124,000 average acreage watered during this period approximately 107,500 acres was supplied by the normal recharge and 16,500 acres by lowering the water table in the sands. This method of estimating the acreage which can be irrigated annually by the recharge agrees well with the Thompson estimate of 100,000 to 117,000 acres, but as stated in his report the data on which the estimates are based are only approximate; it is, therefore, advisable to use the lower figure of 100,000 acres.

The average fall of levels in the shallow wells between the Springs of 1933 and 1934 was not over 0.2 foot. The area irrigated from this source during this period was about 110,400 acres. The rainfall in the Summer of 1933 was 16.55 inches and the estimated amount of water pumped 1.30 acre feet per acre. Estimates based on these data indicate that the annual recharge in these sands is sufficient to irrigate a little less than 100,000 acres, but a check based on a single year is not conclusive, for the rainfall is based on a single station, and summer rains are very spotted. It is possible that a long cycle of dry years could diminish the rate of recharge but the movement of ground water is very slow and it would probably be quite a number of years before such a diminished recharge materially affected the Grand Prairie region if such a cycle should occur.

If the estimate of annual recharge is correct, sufficient water can be pumped from the Pleistocene beds to water approximately 100,000 acres for an unlimited period of time, but if the amount pumped exceeds the recharge, the depth to water in wells will continue to increase to the point where particular wells may completely fail as a source of supply.

The authors of this report have made a study of the record of changes in wells during the past five years, have inspected quite a number of wells in the field, and have consulted with various informed parties. The average annual changes have been computed using measurements made under the direction of the Underground Water Division of the U.S. Geological Survey. The changes have been based on Spring readings, and the wells in Little Prairie, East of Gillette have been ommitted, as it is believed that these are directly affected by stages in the White River.

Table 18 shows the elevations of the static water level in a number of key wells for the years 1929 to 1934. The elevations are referred to sea level and are recorded to the nearest .05 foot. The average date of reading for 1929, 1930, and 1931 was about May 1, and that for 1932, 1933 and 1934 was close to March 1. The table also shows the elevations of the bottom of the shallow well sands, or Pleistocene beds, in all wells for which data was available; the total drop in Spring levels from 1929 to 1934, and the change in levels from 1933 to 1934.

For some wells a complete series of readings was not made. In several cases no readings were made in the Spring of 1934, and the total drop represents only four years, but as the change was small during the last year it was thought better to use a 4-year period rather than omit the record. It is unfortunate that funds were not available to measure a larger number of wells, and an effort should be made in the Spring of 1935 to measure all wells which were measured in 1929. If this is done the 6-year drop for nearly 500 wells can be determined, and a better estimate of the life of all wells can be made than is possible at this time.

Figure 8 shows the U.S.G.S. number and location of the wells on which records for 5 years are available. The actual period covered is about two months short of five years, as the readings in 1929 were made around May 1, while those in 1934 were around March 1. Had the latter readings been made about May 1, the total drop would be a little less, as some rise would have taken place during the two months.

The wells are fairly well scattered throughout the Grand Prairie area, and it is believed that a straight average of the drops will represent the fall in the region with fair accuracy. The largest drops are near Fairmont in T I S, R 5 W. Well 162 shows a drop of over 11 feet and well 169 in the adjoining township shows a drop of 10.40 feet.

The wide variation in drops of wells in the same vicinity should be noted. Well 169 shows a drop of 10.40 feet while well 178 about 3-1/2 miles eastward shows only 5.20 feet, and well 205 about the same distance toward the southwest shows 5.55 feet. In T 5 S, R 5 W, the drop for well 424 is 5.55 feet while that for well 421, about a half a mile distant, is only 1.10 feet. Near the town of Bayou Meto, the drop for well 450 is 5.35 feet, while that for well 463, about 2 miles distant, is 1.65 feet. In T 2 N, R 5 W, well 59 shows a drop of 7.80 feet, while that for well 55, about 2-1/2 miles distant is 3.30. If records for a greater number of wells were available, it is believed that such differences would be even more striking. It should also be noted that the wells near the west edge of the Grand Prairie show the smallest drops.

Table 18.- Spring Elevations of Water in Shallow Wells Sea Level Datum.

Well No.	Elevations of Static Water Level 1929	1930	1931	1932	1933	1934	Elev. of Bottom of Pleistocene	Total Drop 1929 to 1934	Change in levels 1933 to 1934
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
8	200.15	201.25		198.95	198.35	198.50		1.65	+0.15
10	189.80	187.85	186.90	186.40	185.70	186.10	34.9	3.70	+0.40
18	189.60	188.60	187.45	187.90	187.40	186.45		3.15	-0.95
19	187.05	185.65		184.90	184.35	183.45		3.60	-0.90
27	181.80	182.30	180.95			178.80	79.8	3.00+	
28	179.60	178.90	177.90		176.35	177.15	85.3	3.25	+0.80
37	179.45	178.30	177.00	177.45	176.80	175.80		3.65	-1.00
45	170.00	169.90	169.20	170.15	168.25	167.45	82.8?	2.55	-0.80
55	171.50	170.45	166.35	169.60	168.35	168.20		3.30	-0.15
59	165.45	161.40	159.65		158.80	157.65	44.5±	7.80	-1.15
61	191.20	191.55	190.90		191.05	190.05		1.15	-1.00
73	181.55	182.10	180.75		179.60	179.65		1.90	+0.05
78	180.90	181.45	180.30	180.40	179.65	178.95		1.95	-0.70
79	182.00	182.00		179.85	180.00	179.40	31.0	2.60	-0.60
85	162.55	161.65	160.05		157.60	157.20		5.35	-0.40
88	172.40	171.40	170.15			167.80	96±	4.60	
97	168.85	168.70	167.95	166.65		165.60	92.7	3.25	
100	155.20	155.20	153.45	152.95	151.65	150.55	74.7	4.65	-1.10
105	155.80	155.80	155.15	154.75	153.95	153.10	90±	2.70	-0.85
110	156.95	153.85	151.30	152.45	149.70	149.80	60.6	7.15	+0.10
116	151.55	150.40	148.70	147.60	146.50	145.75		5.80	-0.75
122	153.35	150.30	148.45	148.50	147.90	147.55	73.5	5.80	-0.35
126	178.60	178.05	177.90	178.75	178.20	177.35	74.2	1.25	-0.85
127	180.70	180.20	180.00	180.15	179.45	178.85	63.0	1.85	-0.60
131	156.80	156.30	153.15	152.80	151.10	149.70	105.0	7.10	-1.40
135	167.85	168.50	165.80	165.10	164.30	163.40	66.9	4.45	-0.90
141	138.05			134.00	132.55	132.50		5.55	-0.05
144	138.20	136.95	132.80	132.90	130.50	130.75		7.45	+0.25
160	137.55	136.15	134.60	133.40	131.55	131.25		6.30	-0.30
162	139.05	134.80	131.05		129.35	128.00	76	11.05+	-1.36+
169	144.05	139.10	135.50		133.10	133.65		10.40	+0.55
173	150.70	149.75	147.65		146.25	145.75	53.1	4.95	-0.50

Table 18.- Continued.

Well No.	Elevations of Static Water Level 1929	1930	1931	1932	1933	1934	Elev. of Bottom of Pleistocene	Total Drop 1929 to 1934	Change in levels 1933 to 1934
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
178	142.80	141.25	139.35	139.05	137.60	137.60	68.2	5.20	.00
193	152.25	151.75	149.75	149.50	147.20	148.20	55.6	4.05	+1.00
201	No Elev. Ref. point on this well							4.65	
205	138.35	136.20	133.40	134.00	132.80		70.8	5.55a	
210	135.50	132.80	129.70	129.20	128.45	127.70	83.7?	7.80	-0.75
218	151.15	150.40	148.60	147.90	146.70	145.95	85±	5.20	-0.75
223	138.40	135.70	135.05	134.20	131.90		85±	6.50a	
245	133.45	132.05	130.90		126.75	126.85		6.60	+0.10
250	130.75					126.35		4.40+	
257	127.30	125.15	125.00	122.00		121.00	73.0	6.30+	
261	151.10	150.50	148.65	148.35	146.50	145.95	51.7	5.15	-0.55
272	155.55	154.95		153.20	152.50	152.50		3.05	.00
274	176.30	175.80	174.85	175.80	174.80	174.80	98.5	1.50	.00
277	149.65	149.00	145.05	146.90	146.15	145.50		4.15	-0.65
280	136.20	134.60	132.25	132.10	131.45	131.45		4.75	.00
293	127.95	125.70		123.75	122.35	122.65		5.30	+0.30
300	126.25			123.15	122.50	122.00	74±	4.25	-0.50
304	129.55	128.15	126.20	126.00	124.80	124.45	82.5	5.10	-0.35
305	155.25	154.70	153.70	153.35	151.85	151.55	92	3.70	-0.30
306	134.25	132.95	131.45	129.80	129.45	129.35		4.90+	-0.10
311	124.55	123.40	121.45	121.05	119.10	118.55		6.00	-0.55
318	126.85	125.30	123.45	123.25	122.30	121.70	76.5	5.15	-0.60
319	114.45	112.80	110.90		109.50	109.00	67 ±	5.45+	
321	127.20					120.30		6.90	
335	123.45	121.20	119.80	119.50	117.70	118.50		4.95+	--
344	124.22	122.80	121.15	121.15	120.35	119.75		4.45	-0.60
353	136.60	135.40	134.60	134.25	133.25	132.05		4.55	-1.20
355	137.50	136.90	135.60		134.15	133.55	59±	3.95	-0.60
360	145.60	145.05	142.85	143.15	141.55	141.70	55.6	3.90	+0.15
362	147.90	147.60	144.55	145.20	143.15	143.45	64.5	4.45	+0.30
364	No. Elev.	Ref. point on this well						4.45	-0.80
368	132.50	130.05	129.40	128.95	127.80	127.20	95.8	5.30	-0.60
373	126.15	124.45	122.70	121.70	120.60	120.35	91.0	5.80	-0.25

Table 18.- Continued.

Well No.	Elevations of Static Water Level 1929	1930	1931	1932	1933	1934	Elev. of Bottom of Pleistocene	Total Drop 1929 to 1934	Change in Levels 1933 to 1934
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
392	126.40	125.00	123.00	122.50	121.55	122.30	68.1	4.10	+0.75
401	123.00	120.50	118.75	113.00	117.25	116.55	70.0±	6.45	-0.70
411	130.20	129.35	128.05	127.20	126.50	125.95	30	4.25+	-0.55
412	138.15	138.15	136.00	135.80	134.75	135.15	34.8	3.00	+0.40
414	139.60	139.65	138.20	137.60	136.85	137.75		1.85	+0.90
417	140.25	139.65	137.70	136.80	136.95	137.65	34.8	2.60	+0.70
420	142.80	143.50	141.30	140.55	139.35	139.80	76	3.00	+0.45
421	141.55	141.85	140.00	140.75	139.75	140.45	93.7	1.10	+0.70
424	130.10	129.70	126.85	126.45	125.05	124.55		5.55	-0.50
433	124.90			120.20	119.00	118.30		6.60	-0.70
437	129.00	127.40	125.30	125.05	123.35	122.55		6.45	-0.80
440	117.35	116.35	114.45	114.10	112.90	112.50		4.85	-0.40
450	139.65	138.05	136.70	136.15	135.20	134.30	71.4	5.35	-0.90
456	121.30	121.15	119.30	113.50	117.55	117.95	-3.0?	3.35	+0.40
457	125.55		123.00	122.30	121.85	121.25	31	4.30	-0.60
458	129.90	129.30	125.90	125.45	124.50	125.60	20.5	4.30	+1.10
463	151.85	151.30			150.20	150.20		1.65	.00
464	139.05	138.35	138.15	135.90		134.30	81.9	4.75	
473	130.41	130.55	128.55	128.80	128.40	128.65	50.9	1.75	+0.25
475	130.70	131.90	128.95	128.95	128.50	129.30	59.1	1.40	+0.80
480	134.65	133.30	130.20		129.50	130.60	51.0±	4.05	+1.10
486	141.35	141.05	140.55	139.35	139.95	140.40	31.4	0.95	+0.45
492	142.90	141.60	137.30	138.95	137.00	138.70	50.0±	4.20	+1.70
499	149.90	145.60	141.05	144.00	140.80	141.95	28.0±	7.95	+1.15
501	149.05	149.90	143.45	148.10	146.50		15.0	2.55a	

"a" Indicates total drop for 4 years only.
± Indicates that figure may be more or less than shown, due to uncertainty in measurement.
+ 0.15 Indicates rise 1933 to 1934.
- 0.95 Indicates drop 1933 to 1934.
Note.- Several of the wells above shown are believed by the U.S. Geological Survey to be affected by White river, but the elimination of these would make little difference in the final results.

Table 19 shows the average drop in well levels by townships for the 5-year period 1929 to 1934; also the average changes for the year 1933 to 1934. Township 1 S, R 5 W; 1 S, R 4 W; and 2 S, R 5 W in order show the largest drops.

The average drop in the wells shown in Table 18 is approximately 4.5 feet for the 5-year period, 1929 to 1934, and 0.2 foot for the year 1933 to 1934. The average drop of 4.5 feet was obtained by subtracting the elevation of water in each well for 1934 from that for 1929, adding the drop so determined and dividing the total by the number of wells used. The average drop for the year 1933 to 1934 was obtained in a similar manner. An estimate based on the average changes in each township as shown in Table 19, gave almost the same results for the periods mentioned.

The average rise between the Fall and Spring levels in wells for the 5-year period 1929 to 1934 is approximately 2.7 feet. (In this report all annual changes shown are based on the Spring readings, as it is believed that they show more accurately the difference than a combination of both sets of readings.)

Table 20 shows by years the total acreage of rice grown on the Grand Prairie, the rainfall at Stuttgart, and the average drop in well levels. These drops were obtained by adding the annual changes for each well and dividing the results by the number of wells. The total drop for the 5 years, so obtained, is 4.15 feet, or somewhat less than that obtained by taking the difference between the readings at the start and finish of the 5-year period.

This small difference between the total falls for the 5-year period arises from the fact that quite a number of wells were not read for each of the five years; hence the annual averages are not all based on the same number of wells. Of the irrigated acreage shown in Table 20, probably an average of 9,000 acres received water from other sources than shallow wells. The table shows the same acreage irrigated in both the summers of 1929 and 1932 and approximately the same fall in well levels the following springs, although the rainfall varied nearly 5 inches. The acreage irrigated in the Summer of 1931 exceeded that of 1933 by 26,000 acres, yet there was very little fall in average well levels for either year. These differences can be explained in part by the fact that the rainfall shown is for a single station and probably does not represent a true average for the entire Prairie. Also the rainfall is better distributed in some years than others, thus resulting in a smaller amount of pumping. The measurements in 1931 were made about May 1, while those for 1932 were taken about March 1, therefore, the period covered is about 10 months.

Figure 11 shows elevations and contours of the contact surface between the Pleistocene and Tertiary beds. These were obtained from well logs. The map was prepared by the Division of Ground Waters of the U. S. Geological Survey. The Thompson report indicates that a ridge or dyke in this contact surface extends from the vicinity of Bayou Meto to

Table 19.- Changes in Spring Levels in Shallow Wells by Townships

Township Number	Change in Spring Levels in feet		Year
	Years 1929-34	Annual Average for 5 Years	1933-34
T2N, 5W	5.55	1.11	- 0.65
T2N, 6W	2.55	0.51	- 0.77
T2N, 7W	3.30	0.66	+ 0.07
T2N, 8W	3.02	0.60	- 0.32
TIN, 4W	5.80	1.16	- 0.35
TIN, 5W	5.22	1.04	- 0.50
TIN, 6W	4.86	0.97	- 0.75
TIN, 7W	2.15	0.43	- 0.41
TIN, 8W	1.15	0.23	- 1.00
TIS, 3W	4.05	0.81	+ 1.00
TIS, 4W	6.85	1.37	0
TIS, 5W	7.59	1.52	- 0.35
TIS, 6W	5.77	1.15	- 1.15
TIS, 7W	1.55	0.31	- 0.72
T2S, 3W	5.15	1.03	- 0.37
T2S, 4W	5.76	1.15	+ 0.10
T2S, 5W	6.61	1.32	- 0.50
T2S, 6W	4.92	0.98	- 0.82
T3S, 2W	4.26	0.85	- 0.80
T3S, 3W	4.25	0.85	- 0.90
T3S, 4W	5.48	1.10	- 0.58
T3S, 5W	4.60	0.92	- 0.23
T3S, 6W	2.27	0.45	00
T4S, 1W	3.00	0.60	+ 0.45
T4S, 2W	2.48	0.50	+ 0.70
T4S, 3W	4.25	0.85	- 0.55
T4S, 4W	5.27	1.05	+ 0.02
T4S, 5W	5.76	1.15	- 0.31
T5S, 3W	4.00	0.80	+ 0.30
T5S, 4W	5.80	1.16	- 0.70
T5S, 5W	3.33	0.66	+ 0.10
T6S, 3W	2.40	0.48	+ 0.71
T6S, 4W	3.20	0.64	0
T7S, 3W	4.90	0.98	+ 1.42
T7S, 4W	0.95	0.19	+ 0.45

\+ Indicated rise in water level, all other changes are drops.

Note.- A few of the wells used in these averages are believed by the U. S. Geological Survey to be affected by White river stages.

a point about 4 miles West of Hazen, and passes a mile or two West of Stuttgart and Huyin. The contours of this map shows the location of the ridge. The highest portion of the ridge is about 4 miles west of Hazen, and from 2 to 5 miles southeast of Goldman. The lowest point is about midway between Goldman and Bayou Meto, and the lowest elevation shown is 44 feet above sea level.

Figure 12 shows contours of the pressure indicating surface, which is substantially the elevation of the water in the wells, in the spring of 1934. These contours are only approximate, as the number of elevations available was quite limited. The lines show, however, a considerable drop when compared with those on Plate 1 of the Thompson report. The 130 foot contour encloses a much greater area than in the spring of 1929. The movement of ground water is toward a depression centering just east of DeWitt and Almyra. The contours west of this depression show a rather steep slope of the pressure surface. The total drop from a point about 4 miles north of Lonoke to a point 5 miles southeast of Stuttgart is approximately 90 feet.

Table 20.- Acres Irrigated, Summer Rainfall, and Average Drop of Spring Levels in Shallow Wells in Grand Prairie

Years	Acres Irrigated	Summer Rainfall	Fall in Wells in Following Spring
		Inches	Feet
1929-30	127,000	5.54	1.05
1930-31	141,000	2.56	1.70
1931-32	146,000	12.19 +	0.10 -
1932-33	127,000	10.24	1.10
1933-34	120,000	16.55 +	0.20 -
Total	661,000	47.08	4.15
Average	132,200	9.42	0.83

+ Rains fell on 31 days in the Summer of 1931 and none exceeded 2 inches, while in the Summer of 1933 rains fell on 19 days and 4 exceeded 2 inches.

Probability of Continued Drop in Well

Since the well readings of the past 5 years indicate an average drop in spring levels of nearly 4.5 feet, it is important to consider what the amount and rate of the decline may be the next 10 or 15 years. During the 5 year period mentioned the average annual area in rice on the Grand Prairie was approximately 132,000 acres, and the summer rainfall at Stuttgart was 9.42 inches. An increase in rainfall or a decrease in acreage will tend to diminish the fall in well levels.

The average summer rainfall at Stuttgart as shown on table 21 is 11.2 inches. This table is arranged in order of amount of rainfall beginning with the smallest so that the median rainfall of 10.62 inches is easily ascertained. This median rainfall is probably a better basis for comparison as a few summers of heavy precipitation greatly influence the average. It is thus seen that the summer rainfall of 9.42 inches for the 5 year period, 1929 to 1934, was subnormal being 1.20 inches less than the median amount. It is safe to assume that the summer rainfall in the future will come back to the normal amount or may exceed it.

The total area irrigated on the Grand Prairie, while averaging about 130,000 acres since 1916, has varied from approximately 100,000 to 161,000 acres. The rice acreage this year under the allotment plan of the Agriculture Adjustment Administration is approximately 106,000 acres. When much of the land was new large yields of rice could be secured for several years in succession, but now it is necessary to dry drop or summer fallow the land after two crops in rice, if good yields are to be maintained. For this reason it is probable that the future average will be under 130,000 acres, of which over 10,000 acres now secure water from other sources than shallow wells.

Most certainly some increase in the acreage irrigated from small reservoirs will take place in the next few years. This will further decrease the acreage irrigated from shallow wells.

It is thus seen that the rainfall during the next 15 years will probably be greater than that of the last 5 years and that the acreage dependent on the shallow wells will probably be smaller. It appears that these factors will result in a diminished amount of pumping from the shallow well sands and therefore a decreased rate of fall in well levels during the next 15 years. In fact, it seems probable that the acreage irrigated from small reservoirs or other sources will so increase that the drop in well levels will not only be arrested but reversed within this period of time.

The bottom of the Pleistocene or top of the Tertiary deposits is very uneven as shown in Figure 11. The Thompson report states that, "a generalized contour map of this contact surface suggests an erosion surface of hills and valleys". The cross-sections prepared by State Geologist, Branner, also show this uneven condition. These sections include wells situated several miles to either side of the lines. The locations of the wells as shown are their projection on the lines of these sections. The variations in profile may therefore be somewhat exaggerated. (These sections are shown in the Appendix) It is thus evident that the depth of wells even a short distance apart may vary greatly. As previously mentioned the spring elevations of water also vary considerably.

Table 21.- Summer Rainfall at Stuttgart in Ascending Order of Amounts

Year	Inches	Year	Inches
1930	2.56	1912	10.67
13	2.91	99	11.08
24	4.45	94	12.08
25	4.92	14	12.12
29	5.54	31	12.19
09	6.19	02	12.51
1901	6.85		
08	7.36	93	12.64
22	7.50	03	12.64
07	7.78	92	12.77
97	7.98	95	13.00
96	8.29	23	13.09
98	8.63	10	14.89
26	8.67	28	15.11
16	8.90	89	15.24
90	9.00	27	15.82
21	9.34	15	16.09
18	9.36	33	16.55
17	9.68	04	16.59
19	9.75	05	17.22
1934	9.77	1911	18.23
32	10.24	88	18.48
20	10.29	91	19.75
1900	10.62	06	20.39

One of the most important factors in determining the period during which a well will continue to yield a sufficient amount of water is the difference in elevation between the spring water and the bottom of the water-bearing sands, or commonly the depth of water in the well.

The drop or decrease in depth of water from the static level before pumping starts to that which the water attains after the pump has been in operation for some time, is called the "drawdown". The total amount of drawdown depends on the quantity of water pumped and the permeability of the sands. The discharge of the pump divided by the feet of drawdown is termed the specific capacity of the sand. Thus if the discharge of the pump is 450 g.p.m. and the drawdown is 30 feet, the specific capacity is 15 gallons per foot. Those experienced in well drilling in the Grand Prairie have a fair idea of the specific yield of the sands encountered when a well is being drilled. The capacity of a dozen wells in the Stuttgart area was determined as from 15 to 40 gallons, and probably averaged 20 to 25 gallons. With minor exceptions probably all the shallow well sands will yield at least 15 gallons per foot of drawdown. Some data on drawdown in particular wells is contained in Bulletin No. 261 previously referred to.

In artesian areas the water is under pressure, and will rise above the water-bearing sands, while for areas in which a water table exists, the condition is similar to a lake, and the water stands below the top of the sands. It is well established, for artesian conditions, that the capacity per foot of drawdown varies directly with the total drawdown, but for water-table conditions it is probable that the total capacity for equal conditions of permeability and a given drawdown will be less than that for an artesian condition. This is due to a reduction in the cross-section of the saturated sands through which the water moves toward the pump. As most of the Thompson report, it is believed that a yield of 15 gallons per foot would be a safe assumption for any sands in that region.

From the foregoing discussion it is evident that geological conditions, spring levels, depth of water in wells, drawdown, specific capacity of sands and other factors vary so widely that each farm should be considered separately in determining the sufficiency of its shallow well supply of irrigation water.

In determining the sufficiency of the irrigation water supply beneath a farm, the authors recommend the following procedure:

Determine previous spring levels for wells on or near the farm in question; and also the drop in the levels of these wells for the past 5 years. Inquire of those best informed as to the specific capacity of the sands and if in doubt use a yield of 15 gallons. The geological conditions of the stratum beneath each farm should also be given serious consideration. The location of the farm with reference to the contours shown on Fig. 11 and the aforesaid ridge should be noted. As the well levels decline, this ridge will probably diminish the inflow of recharge waters from the west to the area just east of it. In some instances the flow of a well is materially affected by that from another well in the immediate vicinity.

From these data the probable life of a well yielding a given quantity of water can be determined with fair accuracy. For example, if the depth of water in a well from the level of the previous spring reading to the bottom of the sands is 53 feet; the average annual drop in spring levels 1 foot per year; the discharge 450 g.p.m.; the specific capacity of the sand 15 gallons per foot of drawdown and the length of screen 10 feet (which is ample for any ordinary well); the well should yield the 450 g.p.m. for at least ten years, since the depth of water at the end of ten years would be 43 feet, or sufficient to allow a 30-foot drawdown, a screen depth of 10 feet, and an extra 3 feet to cover the drop between spring and fall levels in the wall. As previously pointed out, it is improbable that the average drop during the next 10 or 15 years will equal that of the past 5 years, which together with the low value assumed for specific drawdown, gives an ample margin of safety.

Table 22.- Depth of Water, Thickness of Saturated Sands, Five Year Drop, and Estimated Life, of Wells

Well No.	Depth of Water	Thickness of Saturated Sands	5-year Change 29 to 34	Estimated Life of Well
	Feet	Feet	Feet	Years
10	151.2		3.70	150
27	99.0	88	3.00	98
28	91.9	88	3.25	80
45	84.6	85	2.55	87
59	113.1		7.80	47
79	148.4	148	2.60	208
88	71.8	69	4.60	35
97	72.9	71	3.25	51
100	75.8	76	4.65	38
105	63.1	63	2.70	43
110	89.2	87	7.15	34
122	74.1	58	5.80	29
126	103.2	103	1.25	252
127	115.9	116	1.85	205
131	44.7	37	7.10	3-
135	96.5	96	4.45	63
162	52.0		11.05+	5-
173	92.7		4.95	53
178	69.4		5.20	28
193	92.6	93	4.05	65
210	44.0	44	7.80	3-
218	61.0	38	5.20	20
257	48.0	48	6.30+	6
261	94.3	88	5.15	53
274	76.3		1.50	121
300	48.0	48	4.25+	9
304	42.0		5.10	2-
305	59.6	60	3.70	26
318	45.2	45	5.15	5-
319	42.0		5.45+	2-
355	74.6	61	3.95	44
360	86.1		3.90	59
362	79.0	79	4.45	44
368	31.4		5.30	0-
373	29.4	29	5.80	0-
392	54.2	54	4.10	17

Table 22.- Continued.

Well No.	Depth of Water	Thickness of Saturated Sands	5-year Change 29 to 34	Estimated Life of Well
	Feet	Feet	Feet	Years
401	46.6	47	6.45	5-
411	96.0	96	4.25+	66
412	100.4	86	3.00	100
417	102.8	85	2.60	121
420	63.8	40	3.00	40
421	46.8	30	1.10	31
450	62.9	45	5.35	22
456	118.0	118	3.35	116
457	90.3		4.30	58
458	105.1	105	4.30	76
464	52.4	52	4.75	13
473	77.8		1.75	108
475	70.2	48	1.40	108
480	79.6		4.05	49
486	109.0	79	0.95	362
492	88.7	77	4.20	58
499	113.9	106	7.95	46

+ Indicates that drop was probably greater than amount shown.

The example given assumes the wells to be open or not sealed. By sealing a well and thus preventing the air from reaching the sands, a partial vacuum is formed in the water bearing-beds, which causes an increased flow toward the pump. In this way the yield of a well can often be increased or extended over a longer period of time. A seal is particularly effective when if not sealed the water would be below the top of screen when the pump is operating.

A well of 450 g.p.m. sufficient to water 80 acres of rice, was used in the example given, for it can be shown that a 160 acre field can be as cheaply irrigated from two such wells as from one of a 900 gallon capacity. The drawdown for the smaller well will be half that of the larger. Therefore, such a farm might continue to get sufficient water from the two wells after the discharge of the larger well has fallen greatly below its original flow due to a continued fall in static levels. (See page 32, Bulletin No. 261). In the event that the period during which a well will yield a given flow is over-estimated and the discharge should decline before the end of the loan period, it should be noted that the unpaid portion of the loan is also declining. Hence even though rice acreage must be diminished in proportion to the water available, it is probable that the security as represented by the farm will remain greater than the balance due or the loan. Dry crops can be substituted to partially compensate for the reduced rice acreage. Should the shallow well supply seriously decline there remains the possibility of supplementing the supply with either deep well water or water from small reservoirs.

Table 22 shows for particular wells, the depth of water and thickness of saturated sands in the Spring of 1934, the 5-year change, and the estimated life of a well having a 30 foot drawdown. It is here assumed that the farm on which the well is located could be watered, if necessary, with 450 g.p.m. wells. The minimum capacity of 15 gallons per foot of drawdown is used.

Of the 53 wells shown, 12 have an indicated life of less than 15 years, 9 of 5 years or less and 2 cannot now yield 450 gallons unless the average capacity per foot of drawdown is greater than that assumed. As the wells listed are less than 6 per cent of the total number, there are certainly many other wells which would not last 15 years.

It is difficult to outline the portion of the Grand Prairie which does not have a safe shallow well supply for at least 15 years as the wells shown may not fairly represent the entire area.

Within these townships farms will be found, whose water supply will not be sufficient for the next 15 years, if the drop in well levels continues at the rate shown for the past five years, but there will also be farms that have a sufficient supply. Therefore, the water supply of each farm should be appraised separately.

It is probable that the heavy pumping of the past (1934) summer will cause a further drop in the 1935 Spring levels, notwithstanding the reduced rice acreage. A large number of wells should be measured next Spring and the drawdown determined. Such information is of great value in appraising the shallow well supply for farm irrigation.

A continued drop in shallow well levels will increase the cost of pumping. In the case of motor driven pumps the increased amount of power used will be about proportional to the lift. However, present power rates are materially lower than those of a few years ago, having been reduced from an average of approximately 2.2 cents per k.w.h. to 1.6 cents. The power charge represents about 1/3 the total cost of pumping for electric plants.

In the case of oil-engine plants a drop in water levels would increase the season's oil bill, the other charges remaining about the same. The cost of fuel represents less than 30 per cent of the cost of pumping at such plants.

The average cost of pumping with electrically driven plants is now about $2.00 per acre cheaper than that of 5 years ago, as shown in Bulletin 261. The cost of pumping with the heavy type semi-diesel engines remain about the same except for a small decrease in labor charge.

When the high speed type of light engines are used the operating costs have been considerably reduced, but the life of such engines is yet to be determined.

The problem of securing more complete data on factors affecting the shallow well supply should be given serious consideration. In order to collect such data, funds could be raised by charging an annual license fee of $1.00 per well or about 1 cent per acre in rice. This money could be used to collect field data under a cooperative agreement between the State Geological Survey and the U. S. Geological Survey. A large number of wells should be measured, and the logs, discharges, and specific capacities of the sands recorded. The acreage irrigated by each well should also be noted. The cost would be small in proportion to the value of the data obtained. Those interested in the continued program of the Grand Prairie region should consider the advisability of enacting a law which would make possible the collection of such data. The present question of an adequate water supply for loan purposes covers only a relatively short period, but with the collection of such data, the supply over a long period of time can be considered.